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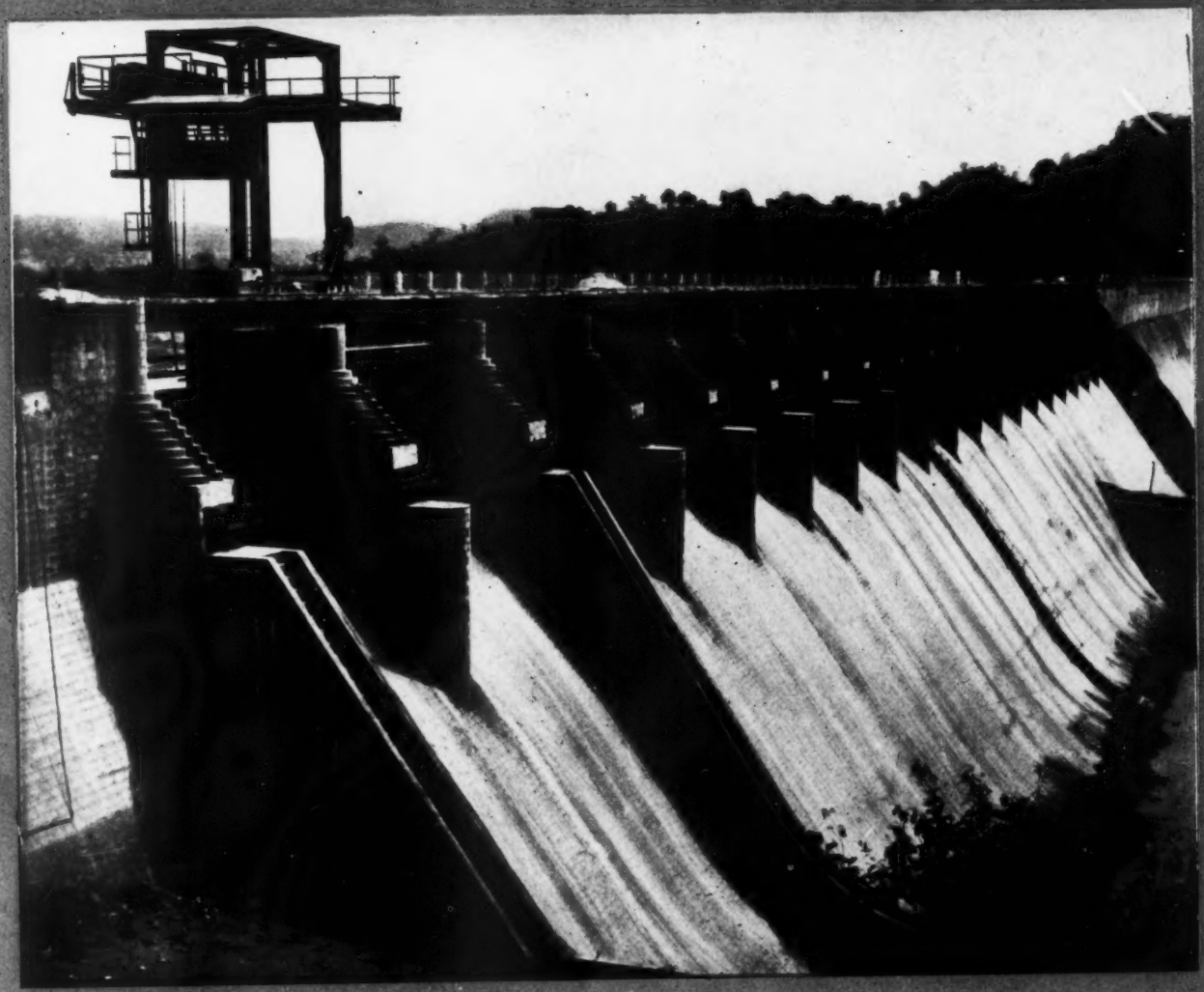
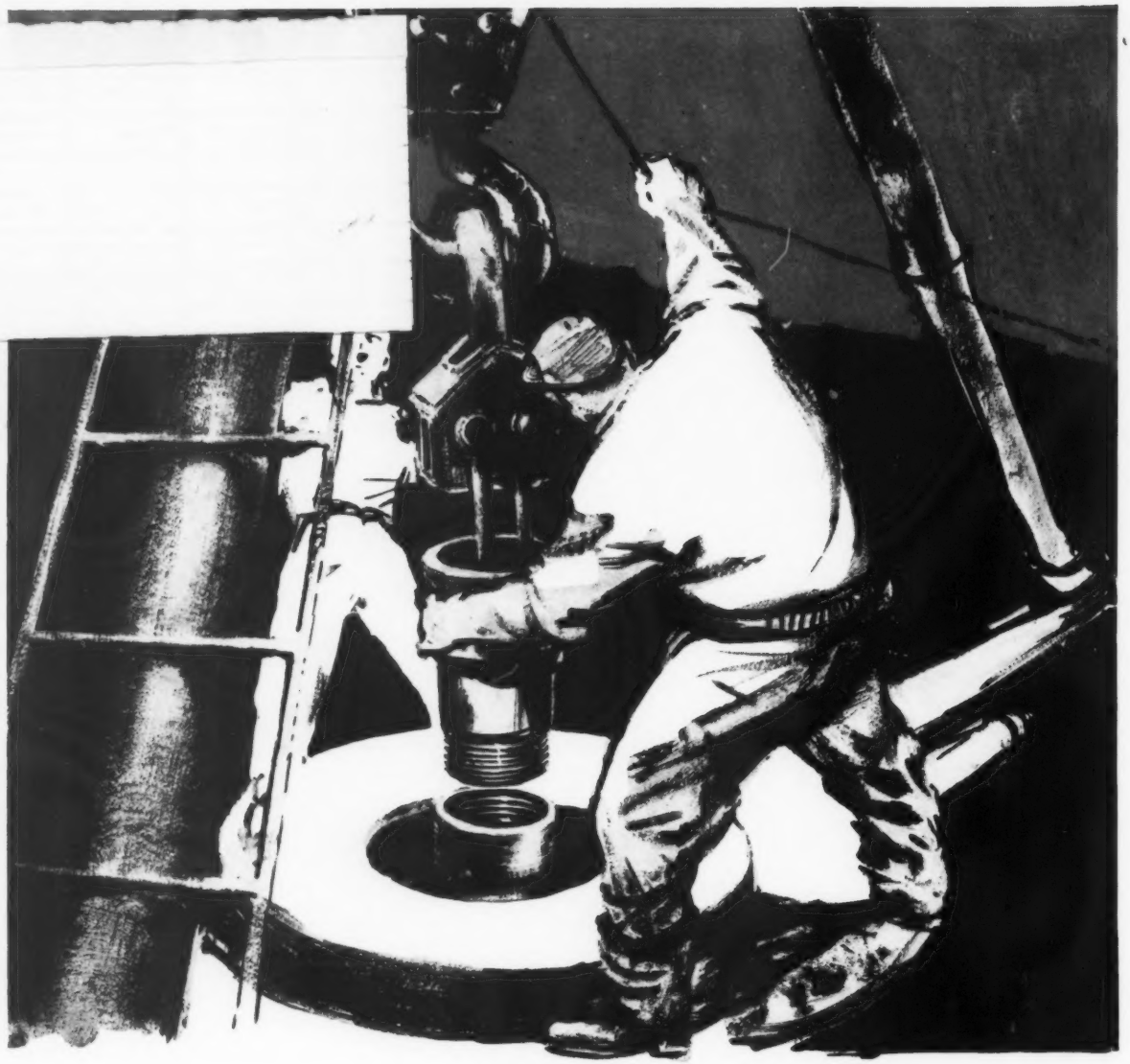
INDIAN JOURNAL OF POWER & RIVER VALLEY DEVELOPMENT

VOL. V, NO. 9 SEPTEMBER 1955 RUPEES TWO



CANADA DAM, WEST BENGAL



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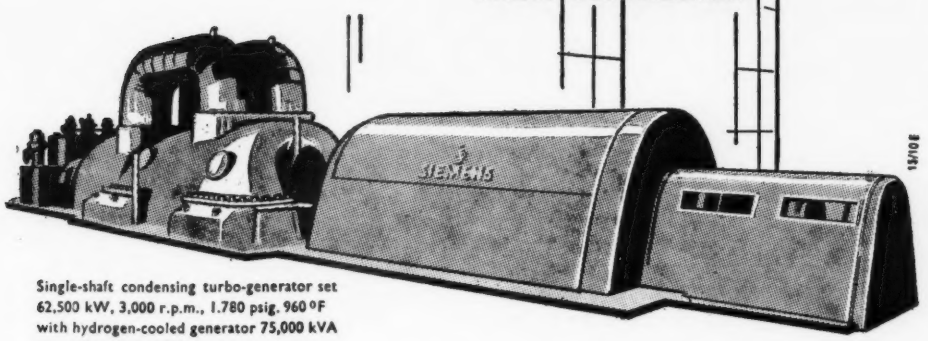

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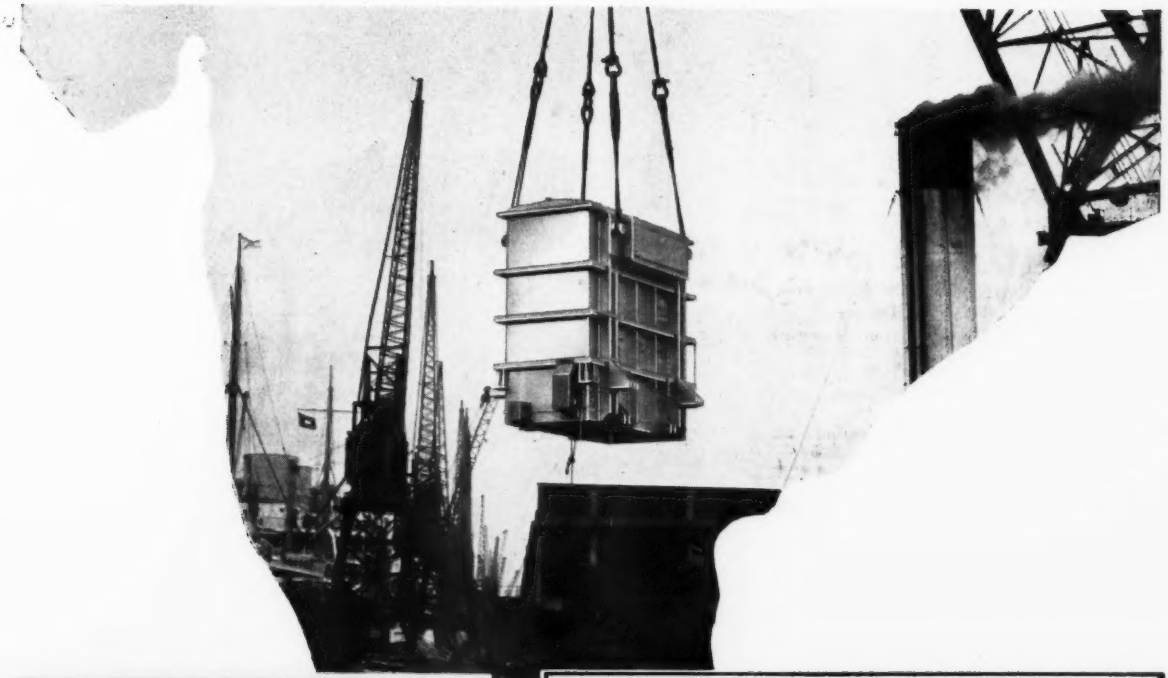

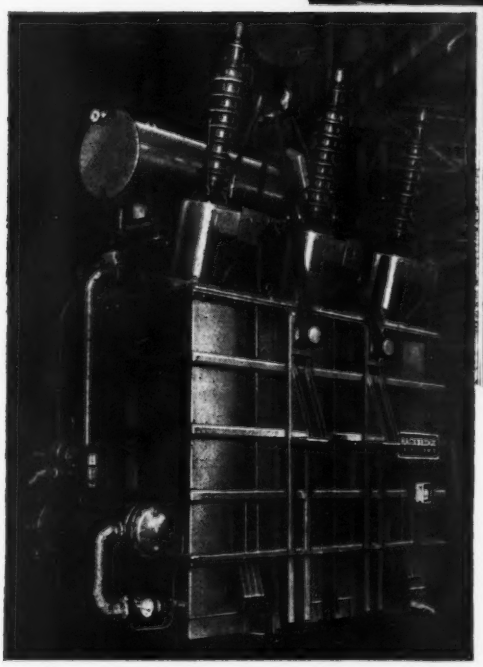

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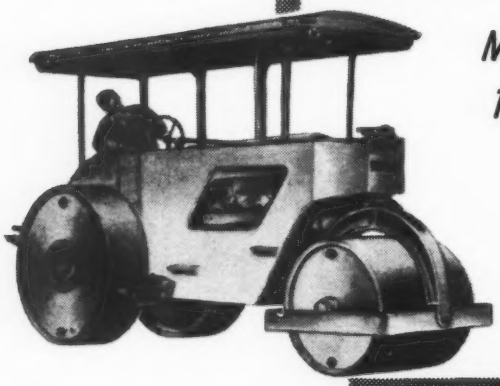

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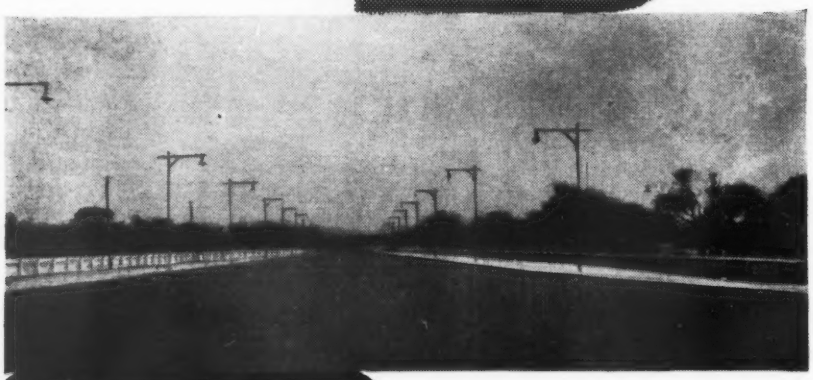

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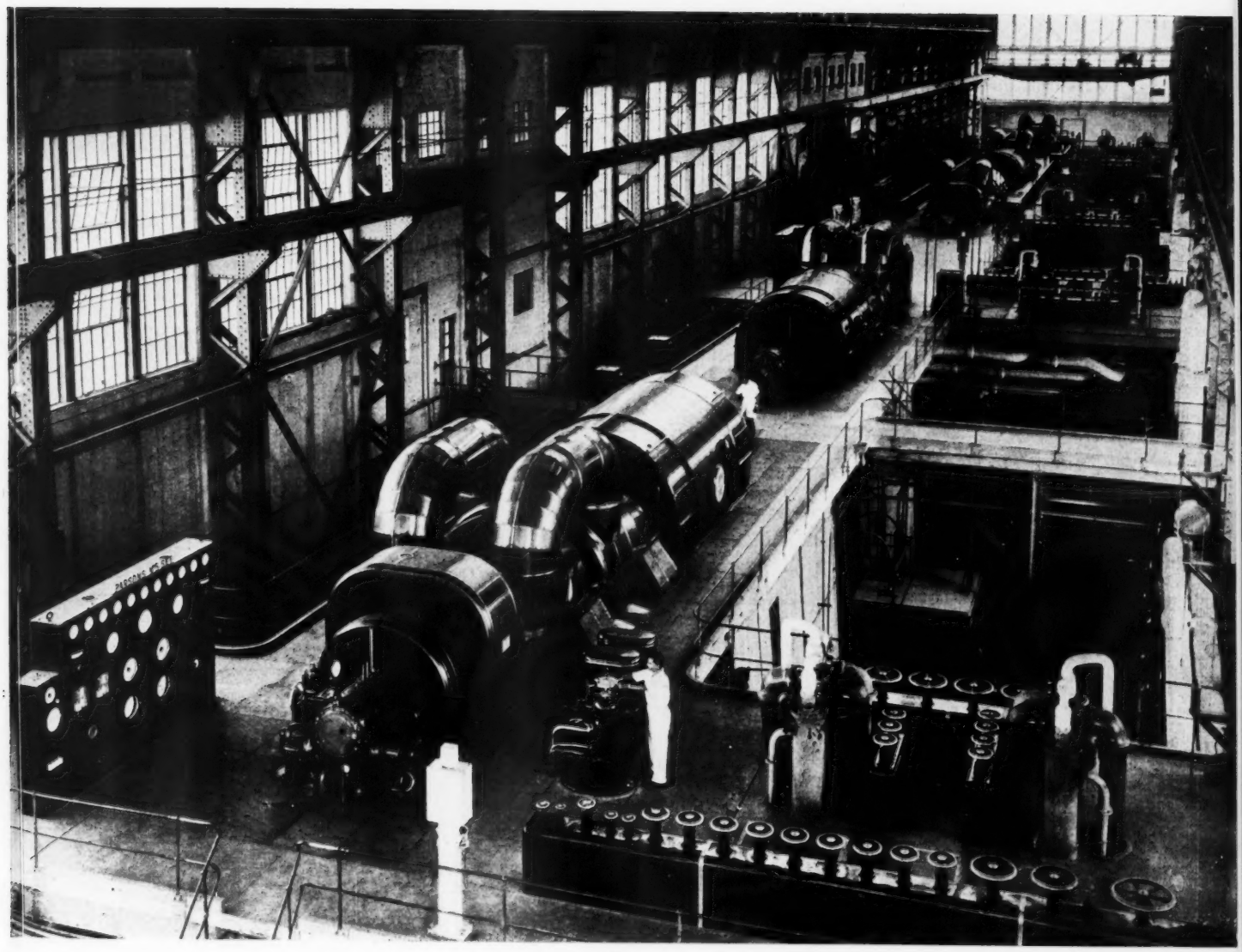

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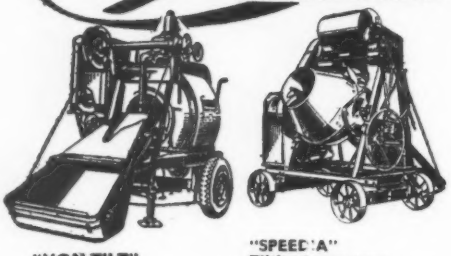

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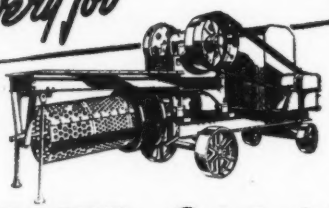

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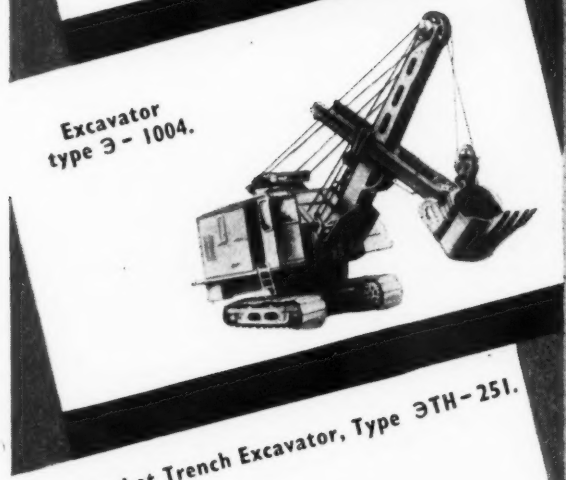

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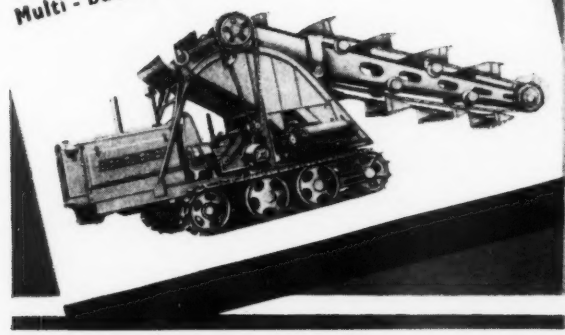

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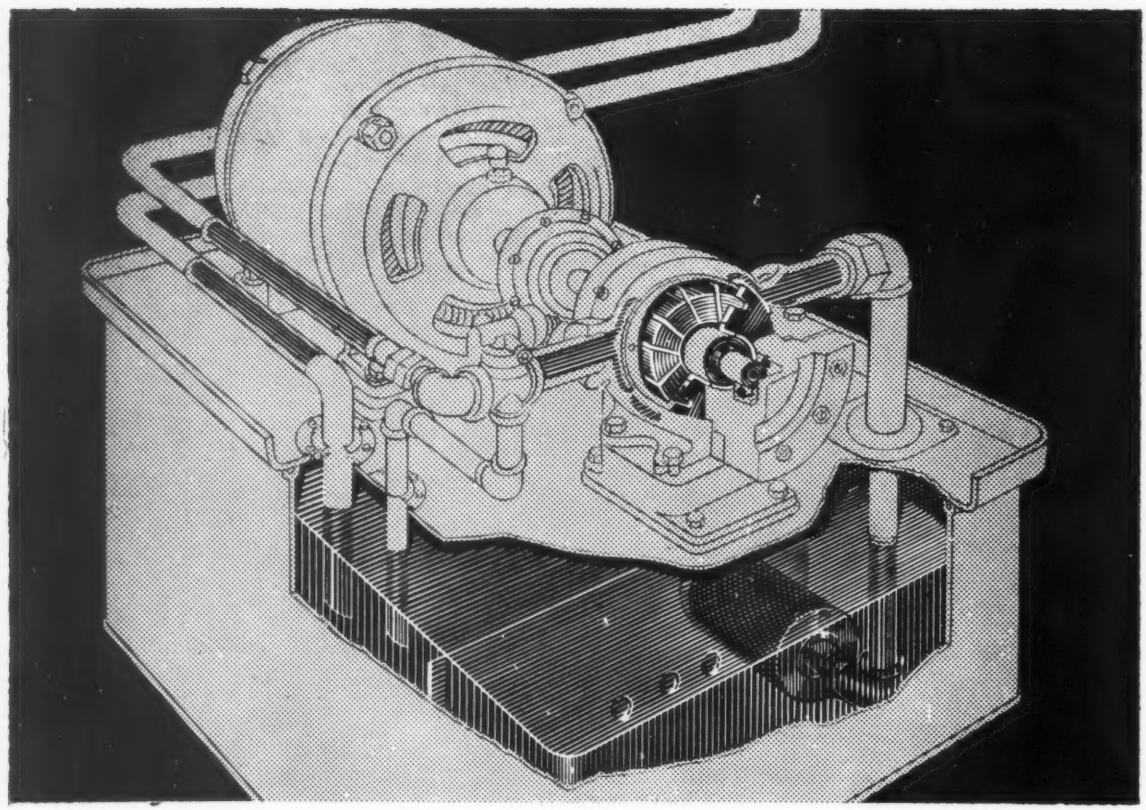

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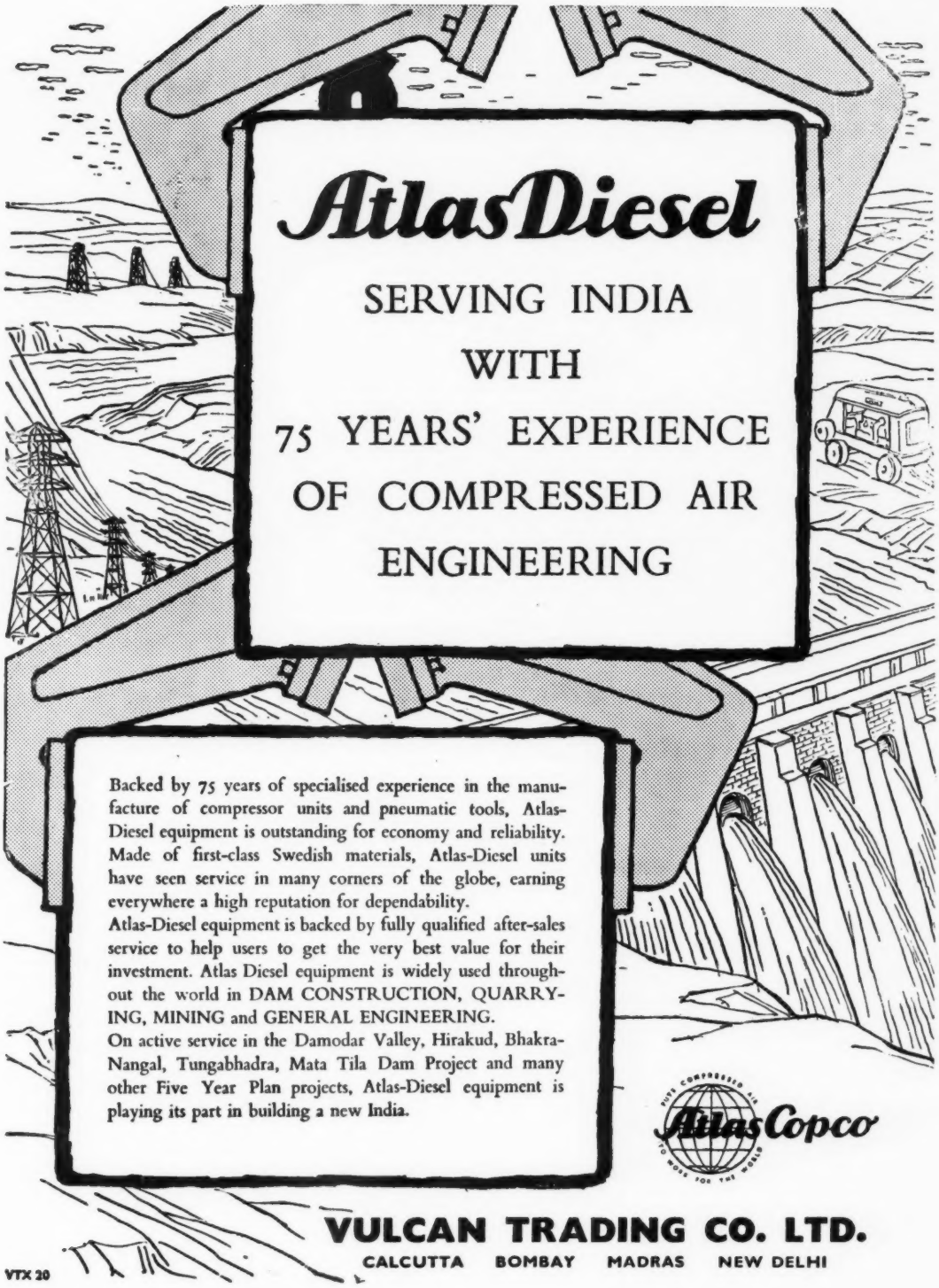

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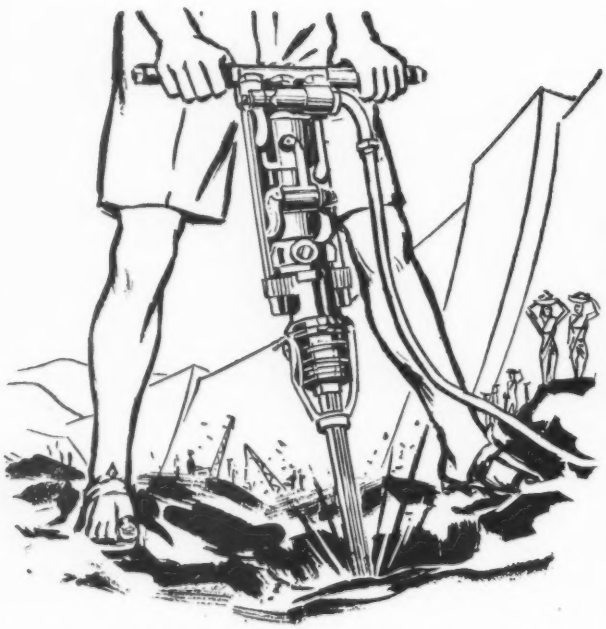

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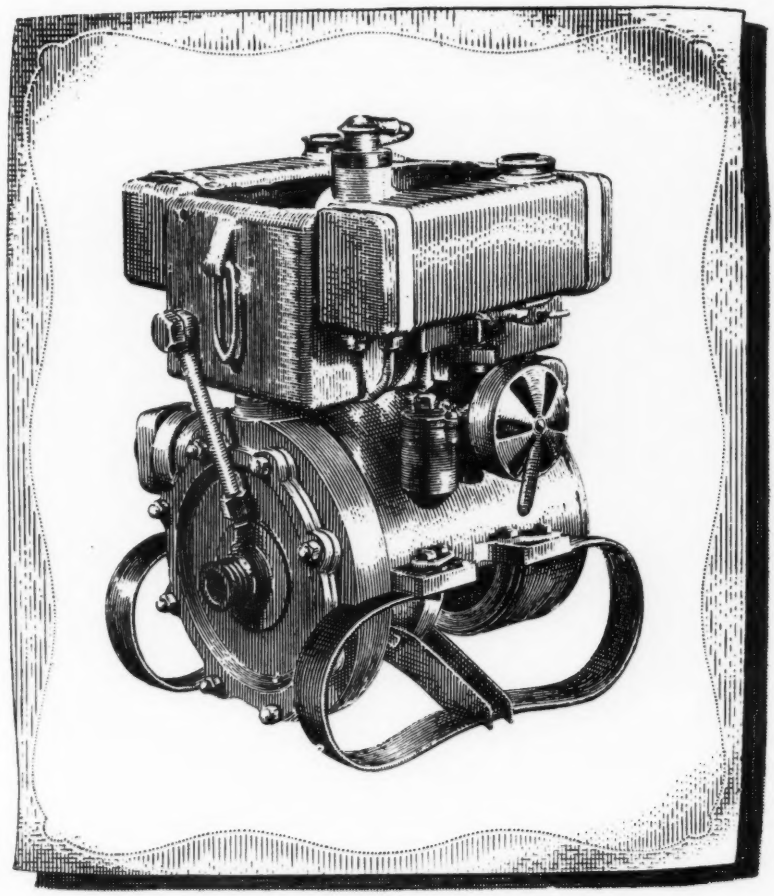

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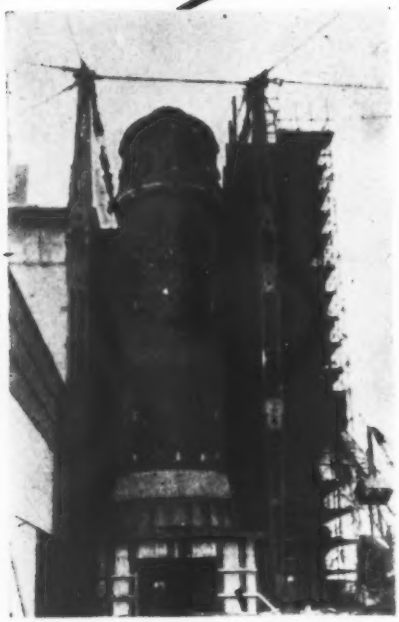
A young Head on old Shoulders

FIRST ATOMIC POWER STATION, at Calder Hall. Impression of reactor house with 80-feet-high steam-raising towers made by Babcock & Wilcox.



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A MONTHLY DEVOTED TO DEVELOPMENT OF POWER & WATER RESOURCES IN ASIA

Editor : **K. K. Sinha** — **P. K. Menon** : Mg. Editor

Vol. V — **September, 1955** — **No. 9**

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In the coming issue : The Engineer's Contribution to the Conservation of Natural Resources *by Sir Harold Hartley*, K. C. V. O., F. R. S.; Studies in the Diversion of Sutlej River *by Dr. H. L. Uppal, Director, T. D. Gulati and B. D. Sharma, Irrigation and Power Research Institute, Punjab ;* Flood Control Projects in the Second Five Year Plan *by Ministry of Irrigation and Power, Govt. of India ;* Role of Forest in Flood Control *by B. Singh, Conservator of Forests, Pepsu ;* National Construction Corporation—*Editorial.*

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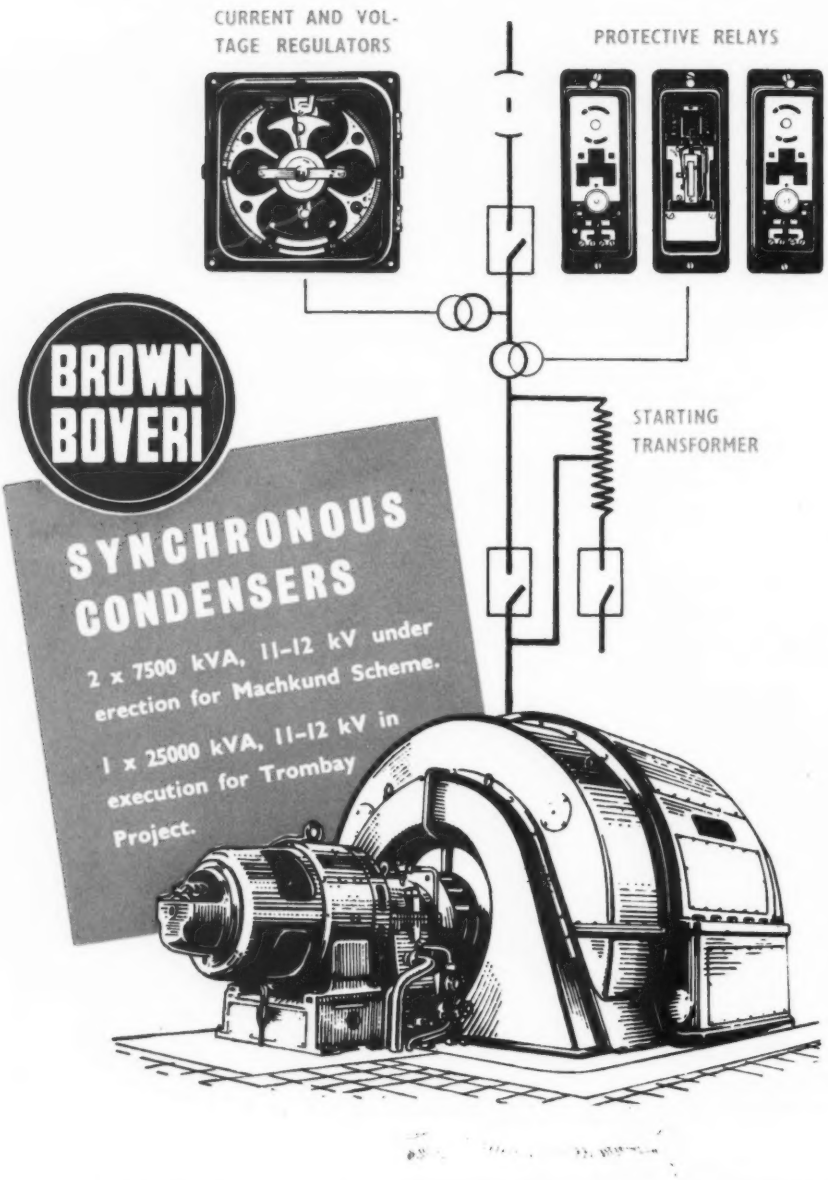

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U.S.A. Moves to Protect Small Watersheds

DON A. WILLIAMS

This is an exclusive contribution specially written at our request by the author. While India and other neighbouring countries are busy building dams and generating hydropower, there appears to be less interest in Soil Conservation and Watershed management than should be. America, which has been quite enthusiastic about large dams now for some time, has by its own experience become more soil-conscious and has taken to soil conservation practices on an increasingly larger scale. The reasons are not far to seek. River and land are interconnected and man needs both. If would therefore be in fitness of things if we studied the American experience in watershed protection and tried to find out if we have something to learn from it. We hope that taken from this point of view the readers will find Mr. Williams contribution of very great benefit.

AUTHOR

In late years there has been in the United States a sharply accelerated movement, by both local people and Government, to combine measures for soil and water conservation with flood prevention in upstream watersheds. To a large extent this movement is the natural outgrowth of experience gained in developing techniques and setting up effective programs for conservation of natural resources over the past quarter of a century.

The watershed, conservation concept, however, cannot be pointed out as something entirely new in the United States. As early as 1891 it was the basic idea embodied in the executive order which provided for setting aside national forest reserves. The Soil Conservation Service, at the time of the agency's beginning in 1933, stressed the importance of planning and treating entire watersheds in erosion-control demonstrations. Many of the country's 2,650 soil conservation districts—farmer and rancher organisations dedicated wholly to the task of applying soil and water conservation measures to agricultural land—have been organised on a watershed basis.

And, since 1947, actual upstream watershed planning and treatment, involving all measures needed to conserve soil and water and control floods, has been underway in eleven watersheds comprising about 30,000,000 acres.

It was not until the early 1950's, however, that the public in general had acquired sufficient knowledge and understanding of watershed problems as related to soil and water conservation methods and value to make it practicable to plan for watershed protection on a Nation-wide scale.

Public Initiative

During this period, many watershed associations were organised by private citizens, usually in communities where damaging floods were common occurrences, or where water shortages become a serious problem during dry years. Some of these associations, working independently, have achieved excellent results in the short time that they have been attempting to solve their watershed problems. Others were unable to raise funds for needed structures and their operations were seriously delayed or discontinued. All encountered the difficulty of obtaining the technical assistance essential in developing sound watershed protection plans on a scientific basis.

Thus it soon became apparent that if the movement to protect small watersheds was to result in substantial benefit to communities and the country as a whole, both technical and financial assistance would have to be provided. Mounting interest was seen in the hundreds of requests received by Congress for legislation that would authorise and provide such assistance in carrying out watershed conservation programs.

Test Projects Authorised

As a first step toward setting up the watershed protection program, the U. S. Congress in 1953 appropriated five million dollars to start combined soil conservation and flood control work in 50 or more small watersheds. The main purpose, as stated, was to demonstrate, (1) the physical and economic benefits of soil and water conservation combined with upstream flood prevention, and (2) to gain more knowledge on the best ways and means of providing effective local-state-Federal cooperation in planning and carrying out watershed programs.

The Soil Conservation Service of the United States Department of Agriculture was assigned the responsibility for approving the areas to serve as "pilot" watersheds in the cooperative program, and for helping the local groups with technical phases of the work.

Don A. Williams *is Administrator, Soil Conservation Service, U. S. Department of Agriculture.*

Part of a small Watershed in West Virginia before Treatment.

Immediately the Service received scores of requests for aid in starting such local projects. The requests came from people in many parts of the country—from soil conservation districts, small watershed associations, and other organisations and groups who indicated their desire and ability to cooperate with Government in such an endeavor.

Demonstration Watersheds

This pilot watershed protection program is now in its second year of operation. It includes 60 small watersheds in 34 states. The areas range from 2,500 acres to more than 200,000 acres. In each of them some responsible local organisation, usually one or more soil conservation districts, gives active support and sponsorship to it.

The pilot watershed program is expected to cost about 29 million dollars in Federal funds over a 5-year period, measured against a non-Federal contribution of a like amount in labor, services, materials, and cash. The 60 projects already are proving exceedingly valuable testing grounds. As demonstrations, they are showing, with increasing clarity, how successful watershed protection projects can be developed by local people with the help of agencies of the government.

The pilot projects are bringing to light also the obstacles to this type of approach that exist in some areas. It appears now that more than two-thirds of the 60 projects will be highly successful. The reasons why some will not succeed are, on the other hand, equally significant to the future development and expansion of watershed protection and upstream flood control.

Nation-wide Program Authorised

Last year (1954) brought the second step to authorise and facilitate cooperative watershed protection on a Nation-wide basis. The Watershed Protection and Flood Prevention Act was passed by the U. S. Congress and signed by the President in August. This law authorises a permanent program by which the U. S. Department of Agriculture provides technical and financial assistance to local watershed groups willing to assume responsibility for initiating, carrying out, and sharing the costs of upstream watershed conservation and flood control.

At the same time other legislative action directly affecting the Nation's conservation program resulted in measures to ease the burden of applying conservation, on farms and ranches, and in watershed projects. An amendment to the Water Facilities Act provides insured loans to meet the credit needs of farmers, and of local organisations and agencies, in carrying out works of improvement for soil and water conservation, irrigation, and drainage. And, a third piece of new legislation enables farmers and ranchers to treat expenditures for many conservation measures as current farm expenses that may be deducted for income tax purposes.

A Cooperative Program

Thus, during the year, the road to soil and water conservation, including upstream flood prevention, has been smoothed and broadened by carefully planned legislation. Some 1,500,000 of the Nation's farmers and ranchers, owners or operators of approximately 425,000,000 acres in soil conservation districts, already have plans and are applying the needed combinations of soil and water conservation practices.

Each year, about 200,000 additional farmers and ranchers start using their land the conservation way. And, America's farmers are beginning now to reap tangible benefits on a wide scale. Their conservation farming and ranching plans enable them to produce greater crop yields from each acre, and at the same time to play an important and satisfying role in the Nation's conservation achievements.

Through the watershed protection and flood prevention program, we in the United States are entering an expanded phase of our conservation program without discarding any of the procedures or benefits of the country-wide program as carried out through demonstration areas and soil conservation districts over the last two decades. The principles embodied in new watershed legislation simply extend the basic concept of soil conservation districts. In this concept there is the pre-eminence of local initiative and responsibility, with teamwork between local, State and Federal agencies involving Federal technical and financial help only when local people request it. The need for Federal technical, cost-sharing, and other assistance to supplement local and State endeavors in the field of conservation is generally recognised in the United States as being in the public interest.

Watershed Protection Defined

The watershed protection program has been based in large measure on studies made over the past few years. These studies show that about three-fifths of the total average flood damage in the country each year occurs on headwater streams and small tributaries. A large part of the damage is agricultural — to land, crops, livestock, buildings, roads and other improvements.

Throughout the United States, about 50 million acres of land in headwater valleys are subject to overflow. These are above the location of any major flood control improvements on large streams. Most of the

The same West Virginia Watershed after treatment.

damage in these smaller areas is caused by frequent small floods that do not gain large headlines or serious attention throughout the Nation. On the average, 75 to 90 percent of the agricultural losses in these headwaters or small watersheds is caused by the kind of floods that occur more often than once in 10 years.

Increasing infiltration and escorting the excess raindrops from the ridge to the valley—down slopes, across fields or parks, through forests or swamps, through small field drainageways and creeks, to allow economical use of water along the way and carry runoff safely to the river—this is the purpose of the watershed protection program.

It includes using each piece of land within its capabilities and applying the practices needed to prevent erosion and make more water seep into the soil. These practices include improved rotations, soil treatments, contouring, strip cropping, terracing, grassed waterways, stubble mulching, cover cropping, pasture and range improvement, diversions, and tree planting and woodland protection.

A watershed protection program also includes adequate flood protection. In the small watershed this can usually be achieved by including in the complete watershed plan the needed small waterflow retarding structures and stream-channel improvements, in conjunction with soil and water conservation on the farm and ranch fields and ranges.

Studies have shown that upstream watershed protection and down-stream improvements such as large dams and reservoirs are closely related. Small structures, of the type designed for upstream watershed protection, by detaining runoff water only long enough to reduce its capacity to cause erosion and sedimentation damage, have little or no diminish-

Contour Farming in Muskingum

A dam with provision for outletting the water into a water spreading system below

ing effect on the overall water supply of cities and industrial centers.

In fact, the problem of the cities is usually one of storage in reservoirs to make the water available when it is needed. Thus, the soil and water conservation measures used in small-watershed protection treatment cut down the rate of reservoir sedimentation, prolong the effective storage capacity life, and have the effect of improving urban water supplies.

At the same time, soil conservation and flood prevention treatment is going ahead in the agricultural land, providing better water conservation and utilisation for production of crops and other purposes that benefit the communities.

Upstream watershed protection on agricultural and forested land, as being carried forward in the United States, is considered complementary to and not a substitute for needed downstream river improvements. At the same time, it is equally obvious that the downstream river improvements cannot be a substitute for upstream watershed protection. The two are expected to work together for proper development and protection of small and large streams and the lands drained by them.

Another side of the watershed development approach to conservation is receiving much interest, especially in drier areas. People are learning that watershed protection does not stop with holding back storm waters; it likewise has the important function of providing for beneficial use of water on the land close to where it falls. This side of watershed development has been termed "drought control". It helps to ensure the indispensable first use of water falling on the watershed for crops, for livestock, for recharging groundwater supplies, and for recreational and wildlife, municipal, industrial and other uses.

Accomplishments to date in 11 large Watersheds

Experiences gained through flood control and watershed improvement work in eleven large watersheds are proving extremely valuable in launching the Nation-wide program. Operations were started in sub-watersheds of these areas in 1947 by the Soil Conservation Service and the Forest Service. Substantial accomplishments have resulted from the expenditure of Federal funds appropriated for these watersheds and of non-Federal costs amounting to about two-thirds as much in the value of labor and materials as well as cash.

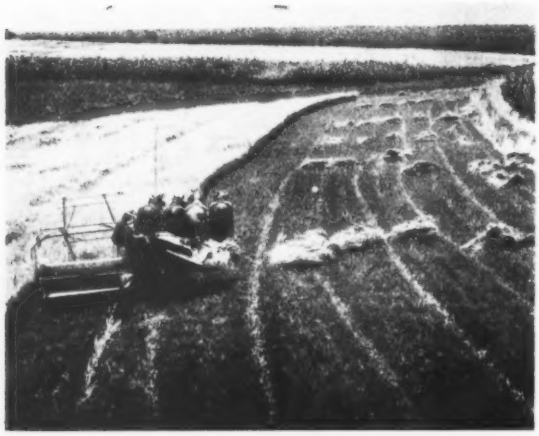
A wide grassed waterway which prevents gullying and at the same time provides hay crops

Grassed waterway safely carries water off fields during heavy rain.

This local-state-Federal effort has made possible soil surveys of 2,800,000 acres. It has resulted in the preparation of basic conservation farm plans on 32,500 farms containing 6,800,000 acres. Assistance given by Soil Conservation Service technicians in the application of conservation farm practices has resulted in 673,000 acres of contour farming, 424,000 acres of pasture and range seeding, and 30,700 miles of terracing—to mention but a few practices applied by landowners and operators.

Additional works of improvement in the eleven watersheds include 205 floodwater-retarding structures, 457 major gully-stabilising and sediment—control structures, 2,521 silt and debris basins, 471 miles of stream-channel stabilisation, and improvement and permanent revegetation by grasses, legumes, and trees of more than 125,000 acres of critical runoff and silt-source areas. The completed 205 floodwater-retarding structures, plus 55 structures placed under contract, will have a total capacity of

Contour strip cropping, with all waterways in permanent grass cover. This system prevents erosion of soils, conserves moisture for crop growth and facilitates rotation of crops and other soil-fertility improvement practices.



Plowing in wheat stubble with attachments, leaving part of mulch and litter on top of ground which aids in protecting soil from drying and serves as a sponge in absorbing moisture. U.S. farmers now practice stubble mulch farming on some 30,000,000 acres.

167,500 acre-feet, or an average of 644 acre-feet per structure. No structure exceeds 5,000 acre-feet in capacity. The cost per acre-foot of these structures has been considerably less than that of most larger dams.

In the 60 Test Watersheds

Accomplishments in the first year of the "pilot" watershed program make a creditable record even though operations covered only about 9 months of the year. Work plans were completed for all 60 watersheds, which contain altogether about 3,000,000 acres. The Soil Conservation Service completed soil surveys on 160,000 acres and helped 269 farmers and ranchers complete conservation plans on 40,673 acres. Farmers applied contour farming on 7,000 acres, 346 miles of terracing, 2,500 acres of range improvements and 500 acres of tree planting. The Forest Service installed nearly 500 stabilising and sediment-control structures and planted more than 200 acres within national forests included in the pilot projects.

The floodwater-retarding structures to be built in the first two years of operation of the pilot watershed program will cost only about 25 percent of total Federal costs during this period. It appears now that about 750 flood-water retarding structures and 1,900 stabilising and sediment-control structures will be required. This is an average of one retarding structure per 4,000 acres and one stablising structure per 160 acres. This distribution, however, would not necessarily apply in any single watershed or regional area. Contracts had been let for many of the structures by the end of the year, and work was in progress in some places.

In carrying out this program, the Soil Conservation Service has obtained the assistance of the U. S. Geological Survey and the U. S. Weather Bureau in installing and maintaining precipitation, stream-

Protection of existing woodlands, and planting new woodlands, are important for conservation and flood-prevention in small watersheds. Selective cutting in this stand of young Douglas Fir provides the farmer with income from the sale of piling and saw-logs, and at the same time improves conditions for tree growth.

flow and sediment-sampling stations to measure the hydrologic effectiveness of the works of improvement. The Agricultural Research Service has assisted in evaluation the economic effectiveness of the conservation measures installed in the watersheds.

Nation-wide Watershed Protection Launched

Public response to the new Watershed Protection and Flood Prevention Act making the program countrywide in scope has been enthusiastic and purposeful. Governments of most states already have provided administrative channels for carrying out the States' responsibility in reviewing and approving applications from local organisations for Federal assistance. Water rights legislation is being studied by a number of State legislatures. Some 200 groups in different parts of the country have made application for assistance on specific watersheds, under authority of the Watershed Protection and Flood Prevention Act. In January 1955, the Soil Conservation Service started investigations and surveys in 25 watersheds, preparatory to the making of complete watershed protection work plans.

A survey, made by the National Association of Soil Conservation Districts, showed that 10,290 small watersheds throughout the country are believed by local peoples to be in need of watershed protection treatment. The survey was made through soil conservation districts, with considerably more than half of the districts reporting. Preliminary advices from the States indicate that more than 500 applications for assistance may be submitted to State agencies or Governors of States for consideration during the first year following passage of the Act. If the watersheds are comparable in general with the pilot watersheds, which average about 50,000 acres, this would represent local interest in the first year in developing watershed projects on some 25 millior acres, more than eight times the aggregate area of the 60 pilot watersheds.

As this new program is being launched in the United States, emphasis is being placed on determining at the outset not only which local people are interested in such watershed programs, but how much they are interested. That is, to what extent are they interested in shouldering the local responsibilities of cost-sharing, of supporting the soil and water conservation program in the watershed, and of maintaining the land treatment and structures after the initial work is completed.

Ultimate success of the watershed programs will depend upon public understanding of the problems and objectives, and upon local participation every step of the way. For, a watershed protection program, in the final analysis, means people working together on a program they design, and in which they all take part. People are part of the watershed.

Soil Conservation Service engineer explains to cooperating farmers of the Dean Creek Pilot watershed project the functioning of a stream flow gauging station. This is an automatic gauge that measures the flow of water over the concrete weir.

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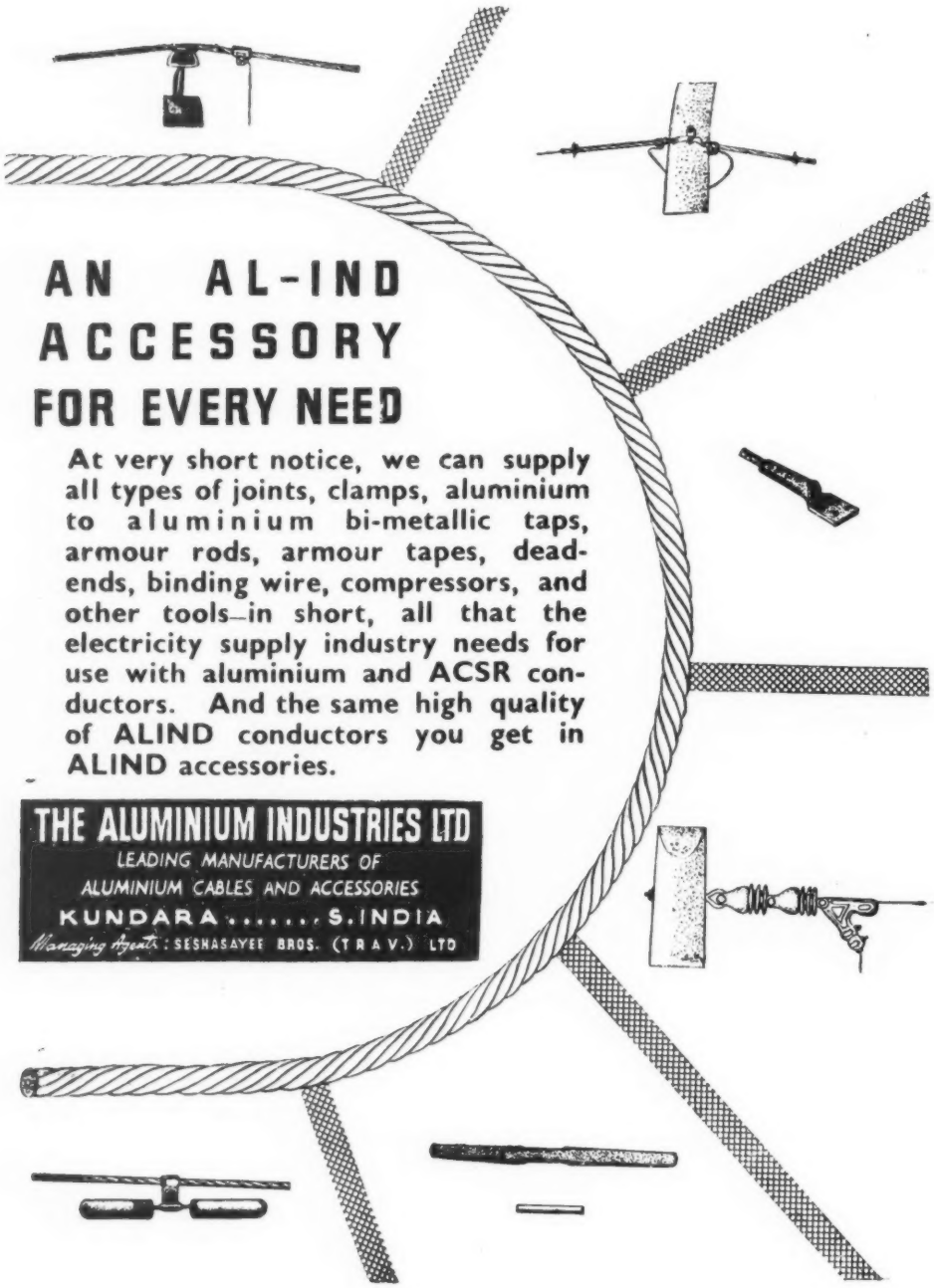

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A New Experiment at Kosi

J. N. SAHNI

Following the Chinese example of mobilising large masses of labour in dyke- construction, a method long suggested by us in 1952, the Kosi Project was the scene of popular participation in embankment construction. The following contribution by a welknown journalist and publicman gives an excellent survey of the task as well as the manner in which it has been undertaken. Being the first of its kind, it was natural that many mistakes were committed. The race against time was also another factor contributing to ignoring many minor points of detail which caused available inconvenience to the workers. Now that rich experiences have been gained, it is necessary to take stock of this, so that this may be of some useful guidance to other project authorities in future. Particularly, the future of Cooperative Labour needs to be specially gone into.

According to the 7-year Plan for controlling the capricious Kosi in Bihar, estimated to cost Rs. 37.3 crores finalised in 1954, the work to be completed after the rainy season of 1954 and before flood season of 1955 was outlined as follows:—

(1) Protective work under the upper reaches and construction of some embankments in the north-east in Nepalese territory.
(2) Construction of a 30-mile road connecting the railway.
(3) Construction of railway line at a cost of Rs. 1 crore and 30 lakhs up to the point of the prospective barrage for the carrying of stones, cement and other material for construction of the barrage.
(4) Construction of headquarters for officers etc.

While all the above items were considered necessary preliminaries to the execution of the 7-year Plan, the Central Government and the Pradesh Government both felt, after the floods of 1954, that they would be completely ineffective if the treacherous and freakish Kosi decided to repeat its destructive pranks in 1955. While work was started and is continuing at a much slower tempo than was originally planned on the above items, the Prime Minister called upon all concerned to apply their mind to the problem of doing something effective to control the floods that might occur in the immediate future while measures were being taken for the completion of the barrage-cum-canal and embankment system.

It was felt that first priority for this purpose should be given to embankments. It was generally agreed that a series of embankments of appropriate height and strategically constructed could be effective in regulating the flood flow of the river. Considering the numerous difficulties experts, however, felt that for at least 2 to 3 years such a project was impractical in terms of available resources.

It was pointed out that in the absence of roads or railways and because of the vast tracts of sand and marshes cut in by numerous unbridged streams and rivulets, it was impossible to move any heavy machinery which alone could expeditiously help in completing the scheme. Shri Nehru, however, felt very keen that a scheme of embankments should be given first priority so that even if the barrage-cum-canal scheme may take a few years to meterialise, Kosi should not be able to repeat the devastation of the floods of 1954. It was Shri Gulzarilal Nanda, the Minister for Planning, who finally took the initiative and, in consultation with the Pradesh Government, took the decision that the embankment scheme should be put through without machines and equipment and with the help of a large number of labourers before the next rainy season.

In a country where such stupendous multi-purpose projects as the Tungabhadra Dam, the Damodar Valley Scheme and the Bhakra-Nangal canal systems involving crores of rupees, outstanding technical skill, and some of the latest mechanical appliances, have either been completed or are under completion, the magnitude and importance of the Kosi project are likely to be obscured.

Capricious Kosi

One must have a clear picture of Kosi before visualising the problems confronting those engaged in carrying out the project or comprehending the purpose of the project itself.

Among Indian rivers Kosi is perhaps the most treacherous and the most unpredictable in the choice of its flood channels. The Ganges, with a length of 1,800 miles, starts from a height of 10,300 feet while Kosi with a length of only 400 miles starts from a height of 18,000 feet. Emerging from the base of the glacier with torrential speed it enters flat land after carrying large quantities of silt and sand, and then suddenly breaks up into several streams and rivulets meandering their way to the Ganges. But for the silt and sand it brings along in its course, the water supply of these new distributaries would have been an excellent means for irrigation. Indeed, between

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People are seen working at the Shramdani Sector, near Bhutaha. On the left hand side where the Flags are seen, these portions have been completed by the Shramdanis.

one devastating flood and another the area fed by the Kosi main stream and its distributaries has alternately enjoyed intense fertility and complete barrenness. Only till recently, before the last two floods, the last one being in 1954, this area was considered the garden of Bihar, known for its rich paddy fields and its endless growth of mango orchards. It was the planters' paradise. It had a population density greater than any other part of Bihar. Today the entire area presents a spectacle of an endless barren desert with vast stretches of sand, marshes and weed. Here and there one comes across a few hamlets created from bamboo and straw in the neighbourhood of dilapidated walls and ruins of what once must have been flourishing towns or villages. The peasants around these places are not only under-nourished and poor, but impress you with their haunting look of fear of impending floods, of famine, pestilence and disaster.

Kosi manifests its freakishness in a variety of ways. Even in normal times it is in the habit of changing its main course swinging several miles from east to west, leaving in its wake large deposits of sand and silt. When in flood, its numerous distributaries join in creating a vast sheet of water 50 to 60 miles in width with a flood flow which has varied from 3½ lakh cusecs to 8½ lakhs in 1954 which was the record.

As an instance of its violence, according to one record, in 1875 the town of Nathnagar in the extreme north-east of Bhagalpur was completely swept away. Its site was left many miles east of Kosi, while 25 years earlier it lay some miles west of it. During this short interval, the river turned fertile fields into arid wastes of sand, sweeping away farms and villages "and changing the whole face of the country from a beautiful landscape into a wilderness of sand and swamp". According to another record, every year the area in which silt is deposited is on an average at least 20 miles wide along the entire course of the river and the quantity of silt deposited is estimated at 37 million tons per annum. An idea of the depth of this deposit may be gathered from the fact that at one place an indigo factory was covered with sand up to the top of its chimneys within four years. At one place the sand dunes were so hollow that, I was informed, an elephant was buried alive.

Tales about Kosi

It is not surprising that for centuries Kosi should have been the subject of strange fables and folk lore, the fables dating back to the Puranas. According to the Puranas, Kosi was a sister of the great Rishi Vishwamitra. She grew into a young and wild woman at a time when Vishwamitra was engaged in his endless battles with the Gods and in a desperate moment was married by Vishwamitra to an old Brahmin. Wild, passionate and youthful she found no happiness in wedlock and hence to revenge herself she has continued through the centuries to rise in mad floods and spread pestilence and destruction in the places of her visitation. Another which is more popular and has been woven into numerous folk songs written and sung by peasant poets, pictures her as a very young, beautiful, wild, passionate maiden. Once when she was having her bath under the glacier she spied a tall, well-built handsome peasant called Rennupal. It was a case of love at first sight. She pursued camping Rennupal to his temporary abode where she found Rennupal camping with his newly-wed wife whom he was taking home. Full of jealousy, rage and passion she has ever since been pursuing Rennupal, in some places called, Rennu Sardar, and leaving death and devastation in her pursuit.

In one of the popular folk songs Kamala, the sister of Kosi, which also happens to be one of the three major distributaries, asks Kosi what her lover Rennu Sardar looks like. Kosi's description is amusing but picturesque. "His face," she says, "is as majestic and grand as a wild he-buffalo, his body is gigantic and hard as flint, his whiskers are twisted in manly pride and are long as bamboo poles: this is Rennupal, my beloved, whom I seek night and day."

According to folk lore and present belief it is Rennu Sardar alone who can tame Kosi, and according to this belief whenever he responds to the advances of Kosi she washes away sand and silt and makes the

area of her romance intensely fertile and habitable. When Rennu Sardar is unresponsive, Kosi gets mad and wild, brings turbulent floods, devastates the entire area by spreading sand and silt and spreads pestilence and disease. According to popular belief, therefore, it has never been in human power to control or tame Kosi, to prevent it from spreading devastation and pestilence and yet on occasions utilise its waters for bringing abundance and plenty.

Ancient Attempts at Control

According to historical records the only outstanding attempts made to build embankments was in the 12th Century by a Hindu King Lakshman the II. This Bir Bandh, as the embankment was called, was 100 feet wide at the base and 10 to 30 feet in height. In length it is estimated at 30 to 50 miles. According to one version, however, the embankment ran all along the course of the Kosi up to the Ganges river. It is not certain when this Bandh was finally swept away or how far it was able to regulate the flood flow of the Kosi river. Except for constructing isolated embankments here and there for the protection of some of the cities, there is no record of any major project having been undertaken to train the waters of the Kosi or to employ these waters for beneficent and productive purposes during the last seven centuries.

Embankments finally approved for completion this year are: (1) a 24-mile embankment in the north in the territory of Netpal where the river is cutting eastward near Baghchora, (2) a 20-mile embankment on the western side starting northward from the rail head of Nirmali and (3) a 25-mile embankment on the east side starting north from the rail head of Supaul. The embankment structure itself was at an average expected to have a 100 ft. base, a 15 ft. top and 12 ft. to 20 ft. height.

Racing against Time

It was November by the time the decision was taken and the stupendous task had to be completed before the 31st of May or else whatever was done in part would be an offering in labour and money to the frolics of Kosi. The first difficulty was the acquisition of land by legal processes from the owners in areas where the embankments had to be built. In the north the problem had its international complications in so far as negotiations had to be conducted with the Nepalese Government both for the acquisition of land and for the surrender of that land for the building up of embankments. Except for an area of 10 miles which has also been recently acquired, the Nepalese authorities, be it said to their credit, acted with great expedition and made the requisite land available in good time for work to be started.

Voluntary Surrender of Land

The first important contribution made by some workers of the Bharat Sevak Samaj towards making the Scheme practicable was to induce the numerous owners of land on the eastern and western sides to make voluntary contributions in lieu of appropriate

Labour is seen coming up ring bundh to complete work immediately when floods are rising. 28th June, 1955.

compensation, of the land on which the embankments had to be constructed. In the ordinary course legal processes would have taken several months and involved several thousands in expenditure. But as a part of voluntary effort this objective was achieved within weeks and without expense.

Heartening Mobilisation of Voluntary Works

Mobilisation of labour was no easy task. At one time, the most densely populated area in Bihar, the Kosi basin in recent years and specially after the last floods has become a virtual desert. The 60-mile embankment on the Burhi Gandhak, also in Bihar, which has recently been completed by the help of labour provided by village Panchayats, although an outstanding achievement, did not for example, present this difficulty. On the Burhi Gandhak villagers just walked out of their hamlets and worked on parts of the embankments in front of their villages and considered the work on the embankment as an additional income. No such incentive was possible on the east and the west side of Kosi. In the north the work had already been given to contract labour since no alternative means of mobilising local labour was possible. The task of clearing heavy jungles seemed formidable.

Considering the peculiar difficulties the effort of the Bharat Sevak Samaj to organise large masses of labour on a co-operative basis and to complete some part of the embankment on the basis of voluntary labour confirmed the authorities in the hope that the task would be completed within the target period. It was, therefore, finally decided that on the west side 20 miles of embankment should be constructed by contract labour, 8½ miles by co-operative labour mobilised by the B.S.S. and half a mile as part of the voluntary unpaid effort by the workers of the B.S.S. On the eastern side 10 miles of embankment was entrusted to the B.S.S. of which 1½ miles was to be completed through voluntary unpaid effort of the workers and 15 miles by contract labour.

During the two odd months that the work has been in progress there has been a spate of fresh difficulties, arising less out of any deliberate desire on the part of any party to slow down the tempo of activity, but more because of peculiar circumstances and of the extraordinary character of the experiment.

Useful Lessons

Even more important than the actual achievement of the scheme would be the many useful lessons which will have been learnt by engineers, the governments concerned, by economists and the workers of the Bharat Sevak Samaj. A great deal of criticism has been levelled against various parties concerned for several acts of omission and commission. Even though such criticism be correct in substance, its unfairness can be studied in the light of the extraordinary character of the undertaking and the unusual manner in which it was undertaken.

A Fair Appraisal

It was sometimes at the end of December that even a Chief Engineer could be appointed to undertake the task. Experts appointed to work out the alignments for the embankments have actually continued to work while the embankments have been taking shape. It was, in fact, only recently that they decided that 15 miles of the embankment on the eastern side need not be constructed this year and that the behaviour of the Kosi should be watched before the alignment along this line is finalised. These 15 miles were entrusted to contract labour.

The problem which confronted the B.S.S. and the administration was to mobilise for both sides of the embankments a minimum of 12,000 workers apart from a large body of *shramdanis*, if the scheme had to be completed within the target period.

The Kosi administration had to make arrangements for a large number of baskets, pick axes and rammers, for several thatched camps for housing the workers, for a large number of officers to supervise and inspect the works. It would be unfair to the Chief Administrator of the project and his colleagues even to suggest that within the short time available to them they did not put in a stupendous effort to meet all the requirements considering the utter lack of transport facilities and the deserted character of the terrain. A continuous chain of water pumps has been installed along the eastern and the western alignment. If there have been, in spite of this, genuine complaints of water scarcity it is because the density of the labour attained at any particular site during a particular period could not be anticipated. The same is true of labour camps, lighting and cultural amenities, medical and health facilities and even tools and implements. In all cases there has been no lack of effort but inability to synchronise supplies with rapidly fluctuating requirements.

It has been a subject of criticism in the press that while shramdanis never exceeded 1,000, co-operative labour has been 35 to 40 per cent of its full strength. The full strength, I am informed, should have been 10,000 workers on each side if the embankment was to be completed before the target date. It is pleaded by the workers of the Bharat Sevak Samaj that initially public enthusiasm was very great and that if some of the steps which on their representation the administration took later had been initially carried out, there would have been no difficulty in keeping up a full complement of workers on both sides of the embankment.

Initially, for example, contract labour was paid 25 per cent more than co-operative labour mobilised by the Bharat Sevak Samaj. This led to a great deal of dissatisfaction and discouragement. Recently, I understand, contract labour and voluntary labour have been placed at par on the western side, and one could see that those parts of the embankment which had been entrusted to the Bharat Sevak Samaj

A large number of people gathered on shramdani sector of Bhutaha during the 3rd week of June, 1955. The photo shows a large number of Shramdanis who are in action to supply earth on the embankment on the 16th June, 1955.

were being completed with much greater rapidity than those entrusted to contract labour. It is for example noteworthy that the first two embankment units that have been completed were the work of B.S.S. co-operative labour.

On the eastern side the entire embankment has been entrusted to the Bharat Sevak Samaj so that it is not possible to judge whether in view of the special difficulties of the eastern side the rates are economical or would not have been contested by the contractors. For my part I did feel that while the actual work on the eastern side is easier than on the western side, labour supply and living conditions are not equally attractive and a slightly higher rate to labour on the eastern side would have been more than justified. This may partly explain the slow progress on the eastern side, although we were assured by the Administrator and the workers alike that enough co-operative labour will soon be available to complete the bund on the eastern side before the 31st of May.

Necessity of Prompt Payments

Apart from rates an essential impetus to co-operative labour is the payment of wages every week. In the case of the contractors such payment are made by cheques periodically while the contractor himself makes payment to his workers every week. The Administrator appreciated the difficulties of the Bharat Sevak Samaj, but it was pointed out that the main difficulty lay in securing large amounts every week from the Treasury in cash, guarding these amounts and arranging for their distribution at the various camps. The administration further did not have the staff of overseers and accounts clerks to make weekly measurements and prepare the vouchers for weekly payments. All these difficulties have been continuously appreciated and are being progressively overcome.

Supply of Provisions

Another problem which had not been foreseen but which confronted the administration at the end of April was the scarcity of rice and kerosene oil in the embankment area resulting solely from short supplies, on the one hand, and large increase in the labour force adding to the population of this sparsely inhabited region, on the other.

An Impressive Achievement

In fact, it is in the background of these difficulties, some inherent in the task itself, and some introduced by inexperience or by sheer lack of adequate time, that the achievement of those engaged in completing the targets at Kosi must stand out in all its impressiveness. If, as I feel confident it will, the experiment at Kosi succeeds, co-operative labour will not only have succeeded in providing a means for completing the task in record time, but will have saved to the administration more than 20 lakhs of rupees, representing the difference between contract labour and co-operative labour in actual rates, on the one hand, and between co-operative labour and contract labour, if contract labour alone were left to dictate the terms for fulfilling the work, on the other.

The Spirit of Shramdanis

The contribution of voluntary labour may be comparatively small. Half a mile of embankment does not seem an impressive length. But in terms of hours of work it represents more than a lakh of rupees'

contribution and several thousand man-hours saved in completing the task. It may be quite true that at any given time the number of shramdanis may not have been more than 1,000 although we were assured that the number was likely to increase to 2,000 to 3,000. But it is something worthy of admiration that even so many public spirited people should be available. The shramdanis have to travel several miles from their homes at their own expense and to walk several more miles through sands and marshes under the blazing sun, carrying their own food, only to add a few hundred more feet to the embankment to protect Bihar from the ravages of Kosi. The fact that such people do exist should be a source of pride to any country.

A.C.C. Contribution

It would be wrong not to mention in this connection the wonderful work being done by the ACC cadets on the eastern embankment. It was a thrilling sight to see more than 6,000 to 7,000 young men of the ages between 14 and 18 cheerfully working in these most difficult conditions of clime and climate and adding their quota to the common task. The number was expected to reach 14,000 by the middle of May. It would be wrong to judge their work in terms of departmental expenditure on the camp of this character. It would be more appropriate to judge it in terms of the spirit which actuated them, keenness and the enthusiasm which inspired them and the discipline with which they conducted themselves.

Economics of Co-operative Labour

A word must also be said about the economics of co-operative labour and some of its peculiar features. It is not only at Kosi that co-operative labour has been employed, but it is at Kosi that co-operative labour presented peculiar problems. In most other places the villages from which co-operative labour was recruited were adjacent to the site, and hence it was not necessary to build special camps, to provide special amenities, or to offer special incentives. In all cases, however, it has been seen that on the whole *co-operative labour under proper supervision has worked more efficiently than contract labour, has eliminated a variety of avenues of corruption, and if it has not been cheaper than contract labour it has at least helped to keep the rate of contract labour down very considerably* and it has certainly speeded up the tempo of execution of the work.

Help in Rural Development

At Kosi a further experiment is being tried. A ten per cent deduction is being made from the earnings of co-operative labour to be paid as a lump sum for some community development work in the village of the co-operative. On the face of it such a deduction may not seem capable of achieving any substantial results. In reality, however, every thousand rupees of deduction thus made would make available to the village 4,000 rupees for community development. Supposing, for example, a village earned a total of 5,000 rupees and had thereby Rs. 5,000 available to it for community development. If the villagers could then pool further voluntary effort by contributing labour of the value of Rs. 5,000 they could claim another Rs. 10,000 from the Government under the development fund scheme of the First Five-Year Plan. Thus they would have Rs. 20,000 available to them for community development schemes.

Close Study called for

There are many other features of the Kosi experiment which deserve to be closely studied since here, for the first time, under extremely difficult conditions, voluntary effort, co-operative labour and contract labour have been mobilised on a large scale over a long period of time for the completion of an urgent but stupendous task.

Kosi is notoriously treacherous, and it may be that this year again, like last year, it may find new channels to spread destruction. The common village in the Kosi area still believes that man-created embankments can never control Kosi. Whether these embankments, therefore, are able to protect the 21,000 square miles threatened by the Kosi river remains to be seen. But the story of the diligent effort put in by thousands of human hands to complete in less than six months that would have otherwise taken years to accomplish would certainly deserve to be written in letters of gold. To think further that several thousands of these men and boys should have faced the adversities of heat, sand and dust, should have walked miles with their bedding rolls and food through marshes with a spontaneous desire to contribute their own voluntary effort in the fulfilment of this stupendous task should not only be a source of inspiration to others but a matter of pride for every Indian. The dignity of labour is coming to its own. (*By courtesy of* Bhagirath)

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Underground Hydro Electric Power Stations

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Electric power generation may well be an index to the economic well-being of a country. The hydroelectric power potential of our country has been assessed at about thirtyfive million kW. This is undoubtedly a highly conservative estimate, especially so, in view of the transbasin development envisaged in modern times. In spite of such a colossal power development possibility, it is rather distressing to note that only a very small percentage of this power potential has been harnessed. Of course, recent astounding scientific discoveries have led to huge power generation possibilities by atomic fission. A pound of fissionable uranium is said to generate energy equivalent to burning about 1,700 lbs of high grade coal. This evidently assures continued development and progress in the field of industrialisation even if all the coal, oil and gas resources of the country are earmarked for several other requirements. This prospective development should not create complacence, especially with regard to hydropower generation and deter progress in that direction. Further, there prevails a popular misconception that hydroelectric power generation is an alternative development to thermal power generation. But experience confirms that the two types of developments are more complimentary. Only such a systematic and well planned generation, transmission and distribution brings the maximum benefits with minimum of expenditure. It is therefore imperative that the vast hydropower resources of the country are investigated for possible development and constructions undertaken with unabated zeal and vigour. True, these projects mean considerable initial expenditure but nevertheless, brings in its turn the benefits many more times the initial expenditure involved. A systematic load survey and an educative propaganda enlightening the people of the country regarding the beneficial utilities of electric energy are essential pre-requisites for a planned development. It is admittedly evident that the demand grows much faster than the supply. Instances characterised by power development of the Grand Coulee Project in U.S.A. more than confirm such a conviction.

Hydropower development is nothing new either to our country. The first major scheme to be initiated was the Shivasamudram hydroelectric station in the Cauvery River Basin in the state of Mysore as early as in the year 1902, with a view to supplying the electric energy to the mining operations of the Kolar Gold Fields. This was followed by several installations all over the country, like the Pykara, Mettur and Papanasam hydroelectric schemes of Madras, the Pallivasal scheme in Travancore, the Ganga Hydroelectric grid of U.P. and the Mahatma Gandhi Power Station in Mysore. But in recent years there is a planned development of the several water courses, multiple-purposed in concept for irrigation, power, flood control, municipal water supply, navigation and many more indirect benefits such as fish culture and recreational facilities.

Most of the rivers of our country, excepting the larger river of the Himalayan Origin, which are fed by melting of the snow during summer months, are seasonal and are noted for their flashy flows. For the success of run-of-river schemes on such rivers, the conduit size provided should be relatively large. Also the power output will be greatly fluctuating with a very small firm power output possibility. This necessitates the operation of a such development in conjunction with thermal power generation for efficient performance at relatively high load factor. Therefore, most of the schemes in our country have been storage schemes. However, there are a few instances of the location of the power station on cannals taking advantage of the topography of the terrain traversed by these cannals. But even these canals have their assured supply of water from storage schemes in the upper reaches.

One type of development characterised by the Mahatma Gandhi Hydroelectric power scheme which utilises the natural fall of the water course has the following features. A storage reservoir assuring continued flow throughout the year for a certain installed firm power output, the power canal, the forebay with the necessary trash arresters, penstocks leading the water to the turbines and the draft tube leading the water to the tailrace are the main structures in sequence involved in the project. Another type of

development characterised by the Mettur hydroelectric scheme has the power station located immediately downstream of the dam with the penstocks located in the dam structure. But the kind of development of locating the power station underground, although practiced and perfected in the continent for years, has not yet been a venture in our country. The possibilities of such a development are now clearly seen. Such a development not only assures increased power potential but also greater economy. The Maithon underground power station, the first of its type in the country is already under construction. A few more such stations are investigated for possible development. The several factors favouring such a construction and a few allied problems are briefly reviewed in the following paragraphs.

Types of Underground Power Station Development

Principally there are two types of underground hydroelectric power station development, one characterised by the development in the Alpine countries, notably Switzerland, from which it derives its name and the other very common in Sweden.

Swiss Type of Hydropower Station

The Swiss type of the underground hydropower station is indicated in the figure (1). The development essentially consists of a small storage and intake

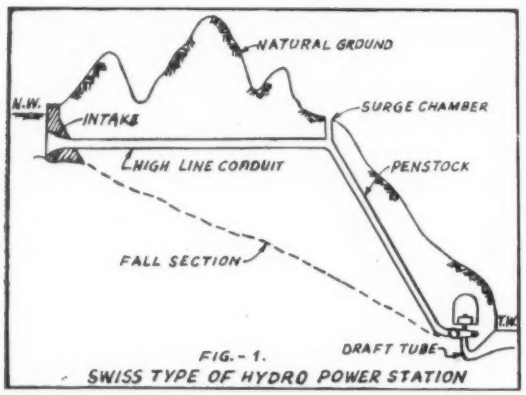


Fig. 1.

works, a long high line conduit, the surge tank, penstocks, power station, draft tube and tailrace. The intake works are generally situated at the commencement of the fall section. The penstocks are so located that there is enough of rock cover. Usually, the heads available for such a development are very high, ranging from four to six hundred feet. The high line conduit is bored with a flat gradient upto the surge tank. Long tunnels and very steep penstocks involve considerable loss of head due to friction, of course negligible when compared with the high heads available. Invariably the intake structures are not very elaborate and considerable economy is effected in these though long tunnels are obligatory.

The Swedish Type of Hydropower Station

The Swedish type of underground station development is indicated in the figure (2). In this type of

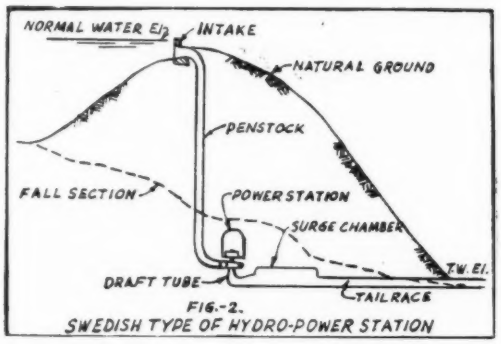
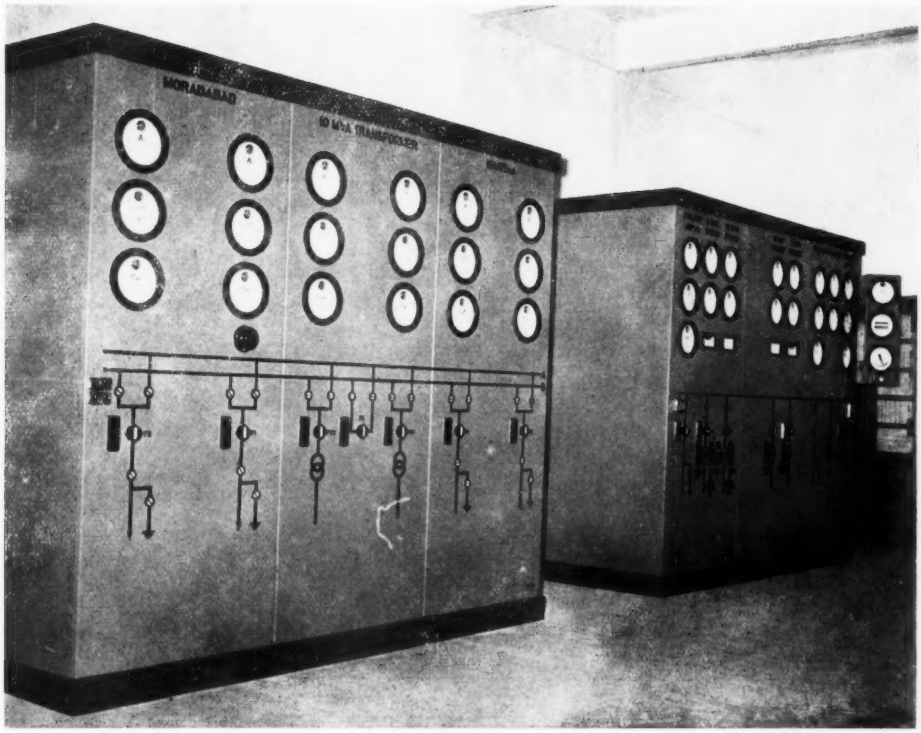


Fig. 2.

development the intake is located roughly midway between in the fall section, and the power station is located directly below the intake works underground and connected to a longer tailrace tunnel with the necessary transport shafts and tunnels. The heads available for this development seldom exceed 150 to 200 feet. Invariably more than one site offer themselves as alternative sites for similar development. The final location of the intake works and the penstocks immediately downstream have to be decided upon, after extensive investigations with reference to topography, subsurface explorations and petrological investigations to ascertain the type of available rock are conducted in adequate detail for each of the probable sites and cost estimates compared. The site so selected finally should provide the maximum benefit with least expenditure. As the tailrace tunnel is long compared to the headrace the surge tank is situated at the downstream of the generating station. This surge tank should be of sufficient capacity to effectively take care of the variations in the tailwater elevation.

Factors favouring the Selection of Underground Stations

The principal electrical machinery such as the generators, turbines, transformers and switching equipment; the auxiliary electrical and mechanical equipment; station service and operating machinery such as the gantry cranes for operating the intake service and emergency gates and draft tube stoplogs, the power station crane for handling the equipment inside the station; and the other auxiliary station service equipment are all the same whether the preposed station is underground or on the surface. Not all situations lend themselves suitable for underground development. Topography of the terrain and the geology of the subsurface formations have prodominant influence on the selection of an underground hydropower station. In addition, the following factors favour the location of the power station underground.



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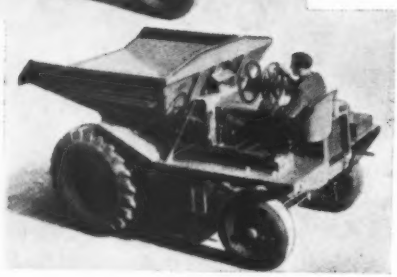

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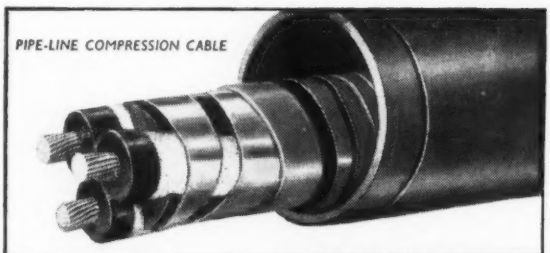

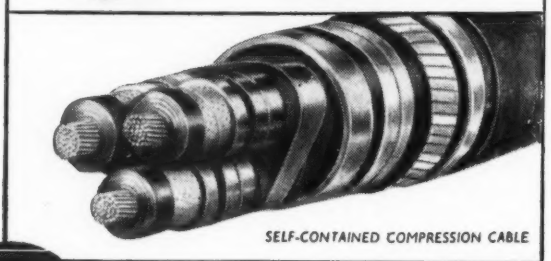

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(*a*) If the cross canyon profile at the site of the proposed development is very deep with steeply rising sides, it becomes difficult to secure adequate space for suitably housing the power house, necessitating the same to be located underground. It is interesting to note in this connection, that in France some power houses are located under the skyjump spillways, right below the shooting jets. This of course presents complicated access problems to reach the station premises.

(*b*) If the dam structure built across the water course, to effect the necessary storage, is an earth dam or earth and rockfill structure, considerable difficulty will be experienced to locate the water passages in the body of the dam. The seepage along the plane of contact may become excessive and result in dangerous water losses, eventualley ndangering the structural stability of the dam. This necessitates the construction of a separate intake structure. The river diversion works in such a construction normally comprise of tunnels routed through the abutting hills, advantage being taken of the topography of the site. These tunnels may perhaps be utilised as tailrace of an underground power station with advantage and incidental economy. The available head may considerably be increased for development, may be with a slight increase in the length of the tailrace tunnel.

(*c*) Availability for sound igneous rock types of tunnelling work favours the choice of an underground station considerably. Igneous granites and gneisses are far superior for tunnelling than the sedimentary and the softer rock types. Not only is drilling and blasting difficult in these softer rocks but the charge consumption is fifty percent more in such cases. With the recent advancements in the mechanical appliances for drilling, charging, blasting, mucking and transporting the broken rock, tunnelling has, ofcourse, become easier and perhaps more economical. The use of tungsten carbide steel for drill bits has revolutionised the entire tunnelling process, resulting in speedy efficient work with attendant economy.

(*d*) The tunnelling work and boring for an underground station can be carried out round the year, without being hampered by seasonsl variations, as the entire work is free from the effects of wind and rain. This helps a great deal in achieving the object earlier than it would have been, had it been a surface station. Thus, not only is the overall period of construction reduced, but the project begins to yield positive returns earlier. Further, the construction of the dam and the power station works do not overlap as they constitute two absolutely independent units.

(*e*) Maintenance cost of the rock tunnels and even concrete parts which are not exposed to the severe action of the weathering agents such as sun, wind, and rain, is comparatively less than that for their counterparts of a surface station. Also the depreciation of rock is much less than for concrete and thus the underground station saves considerably in maintenance and depreciation expenditure.

(*f*) The adoption of the set practices and type designs greatly supresses the initiative and enthusiasm for original work and creative ability. For a progressive country, it is very essential to develop a spirit to achieve something spectacular and an insight into enterprise. Flexible progressive outlook and research temperament is bound to deliver the goods rather than rigid conventionalism.

(*g*) Last, but not the least, the greater security achieved against aerial bombardment during periods of international conflicts considerably influences in favour of the underground power station, though by itself, it is not a deciding criterion.

Types of Station Installation

There are two main types of station installation, the essential distinguishing feature between the two being the turbine shaft. In the first type, the turbine shaft is vertical, with the generator situated above the turbine and hence derives its name as the vertical installation. The second type entails a horizontal setting of the turbine shaft, with the generator and the turbine situated side by side. Each type of installation has certain decided advantages over the other. Figure (3) indicates line diagrams of the tow systems of installation.

The horizontal setting is not favoured for high head plants. If the head becomes more than 100 to 150 feet, the shaft size required will be heavy with the necessary bearing structures. These render the installation beyond a certain size, prohibitively uneconomical. Aslo, the vibrations become excessive and hence not desirable. But for this objection, the horizontal setting scores high in comparison with the vertical installation, the errection being relatively simple, easy and economical. Obviously, the entire arrangement in the horizontal setting is simple and elegant, as it avoids the cumbersome structures seperating the generator and the turbine floors. The generator is held suspended from the shaft permitting a better and a more effective generator cooling. Further, in the horizontal setting, the loss of head due to the two elbows marked (1) and (2) in the figure (3), the former in the penstock and the latter in the draft tube, which are characteristic of the vertical installation, is avoided. This contributes considerably to the power output and high efficiency. Another conspicuous advantage with the horizontal installation is that the surge chamber is located away from the generator vault. The proximity of the surge tank to the generator bay, which is the case in a vertical installation, is not very much desirable. Though the chances of an explosion in the surge chamber may not be imminent, from considerations of safety, it is always preferable to locate the same as far away from the generators as possible. This is ideally achieved in the horizontal

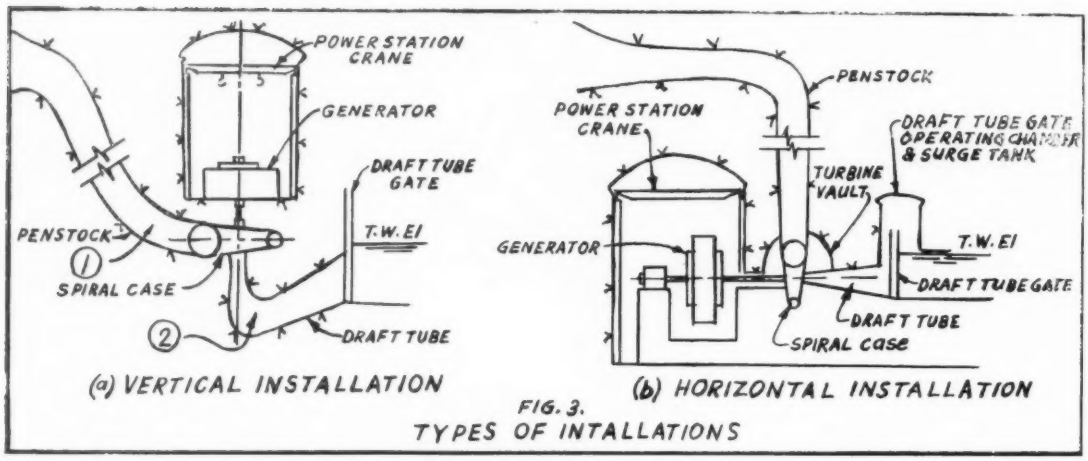


Fig. 3.

setting. In this installation the draft tube gate operating chamber itself may conveniently be utilised as a surge chamber. If a shaft is sunk from the surface to the chamber, the resultant damping effect on the pressure waves is ideal. The shaft may advantageously be used for access for the gate operation personnel as well, by providing suitable stairways and ladders. Such a shaft may not be necessary if the surge chamber is adequately designed to effectively take care of the variations in the tailwater elevations, consequent upon the load changes.

As far as possible, long stretches of horizontal pressure tunnels should be avoided, as they give rise to serious water hammer effect. With the fluctuation of load on the station, the water flowing through the system varies. Such sudden fluctuations give rise to pressure waves. The effect due to such a disturbances should be minimum for an efficient performance of the station. A surge chamber ably helps to minimise such pressure variations. There are three principal types of surge tanks—the simple type, the enclosed or the compressed air type and the differential type of tank of which the last named is coming into greater prominence, because of its simplicity, reduced dimensions with consequent economy and efficient performance. A detailed study of the water hammer problem and its bearing on the hydropower station development: detailed descriptions of the several types of the surge tanks and a comparative study of their merits and defects are however, beyond the scope of this article.

Construction Technique

Tunnel construction, shaft sinking and boring through rock considerably depends upon the type of rock through which the boring has to be carried out. For tunnel driving through harder and better varieties of rocktypes, the bottom heading and overhead stope method may be adopted. A fairly large pilot heading may be effected to facilitate easy movements of men and machines. But, if the rock is not of a high quality, top heading and underhand stope method may be adopted with advantage. If the tunnel size is small enough, just sufficient to facilitate the movement of the equipment, full face heading may be effected. For a satisfactory execution of any project work, a master plan incorporating the minutest details and a systematically scheduled programme of execution are essential. Otherwise, it will result in bits of incoherent work, the correlation amongst which becomes very difficult. For a speedy execution, more than one face of attack may be established. The power station may be approached from the intake side. After sinking the shafts for the penstocks an entry into the turbine vault is effected, whence work can be continued in two directions, one towards the generator vault and the other towards the draft tube and tailrace. Another face of attack may be established from the tailrace side in the reverse order. The station may also be approached by way of the access tunnels and shafts. For constructional convenience, a mucking shaft is usually sunk at about the middle of the power station, which provides an additional face of attack for boring through the power station zone. This constructional feature greatly helps an efficient and economical removal of the muck and rockspoil resulting from the accurate layouts are absolute essentials for a satisfactory construction. Adequate provision for ventilation and frequent circulation of fresh air are necessary during construction stages as well. As the rock cutting proceeds, simultaneous arrangements for transport of broken rock and debris to outside of the station are necessary. Careful planning and execution of the several phases of tunnelling and boring such as drilling, charging, blasting and removal and transport of the broken rocks, not only helps efficient and economical working but saves untoward accidents. Blasting should be controlled, the hours of blasting being prescribed. Prior to blasting, sufficient forewarning should be given by the aid of sirens and bugles. Efforts should be made to remove all loose rock material during clearing process.

Tunnelling Equipment

Various mechanical devices such as pneumatic drills, power shovels, mechanical muck loaders and dumpers are used in a high speed construction. Winches and hoists are used to raise the muck and broken rock through shafts, using tipping wagons. If the depth of shaft is relatively small, cranes may be used for the purpose. Standard gauge track lines are laid out on the surface for transporting the muck to required places. The number and size of the several equipments and plant have to be carefully designed, consistant with the nature of subsurface formations, the magnitude of the job and the time stipulations in which the work has to be completed. It is always preferable to slightly overplant the equipment. Various kinds of pumps such as steam pulsometer, electric, compressed air or rocker arm, are used for sinking shafts. As the pumps lose a high percentage of efficiency if their suction head is increased beyond 15 feet, they are usually lowered as the work progresses, keeping the suction head constant. Constant supplies of water and compressed air at moderately high pressures should be maintained at the various faces of attack, for a nonstop high speed construction. Inflamables like diesel or petrol should not be used for machinery on such constructions because of the danger caused by exhaust fumes. Careful planning of the equipment layout is of utmost importance for an efficient and economical construction, obviating the duplication or overlapping of the several operations involved.

The following are some of the salient features that are commonly found necessary for an efficient and satisfactory construction of an underground hydro-electric power station.

Curtain Grouting

As has been seen from the previous paragraphs, the Swedish type of the underground power station is more likely to be affected by seepage pressures from the headwater side, because of its relative proximity to the storage reservoir. This is further aggravated from considerations of reduction of the horizontal stretches of headrace tunnel to minimise the water-hammer effect. A judicious balance should always be aimed at with additional precautions such as a highly impervious grout curtain. Split-space method of grouting under the pressure may be adopted to achieve a water tight diaphragm. However, such a curtain may not altogether stop the seepage and as such provision should always be made to suitably guide the small extents of seeping water to the station pump shaft wherefrom it is pumped out to the tailrace. A perfectly leak-proof ceiling may be constructed to protect the precision equipment and the operating panels and boards.

Concrete Lining

Concrete lining generally is not required if the rock strata is sound and absolutely free from fissures, cavities, solution channels and the like, which are more common to sedimentary rock types. But in places where it is essential to protect any loose rock, concrete lining may be necessary. The power station roof is usually designed as an arch and is constructed of adequately reinforced concrete. The station may be lined walls or left as such, if the appearance does not look very rugged. However, columns have to be erected at regular intervals on either side of the station to accommodate the crane rail on which moves the power station crane with the crab mounted on it. The crane capacity is fixed with reference to the heaviest of the machinery it has to handle during erection time. Extensive study regarding the capacity of the crane, crane clearances etc are essential for a satisfactory performance. Lining of the water carrying tunnels greatly assist in improving the coefficient of flow through the lined tunnels and also restrict the seepage losses. As a result, the tunnel dimensions could be considerably reduced. However, it has been observed, that with the adoption of mechanical equipment for tunnelling work, a larger sized opening is relatively more economical. For the rest of the surfaces, a smooth finish giving the walls a nice appearance will be enough. Guiniting may offer an economical means of providing this layer. At places of questionable strength, extensive lining may have to be undertaken, with provision for subsequent grouting under pressure. This necessitates the commissioning of a pressure grouting pan as an addition to the equipment required.

Auxiliary and Station Service Equipment

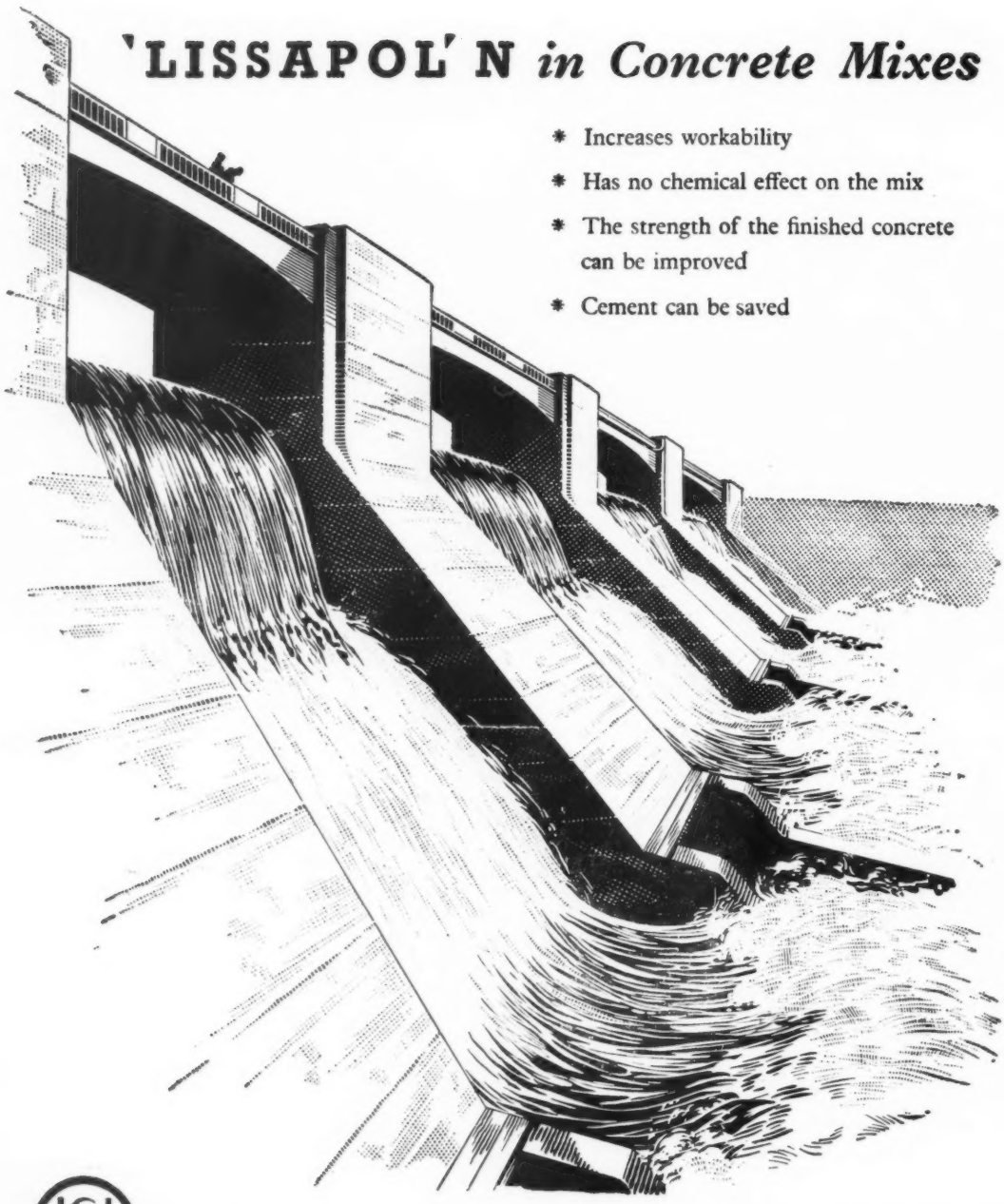
The auxiliary and station service equipment required are the same, whether the station is underground or on the surface. The excitors, low tension switchgear and transformers, the battery sets, the motor generator standby etc are all located in the underground station in their relative positions. As considerable space is required for the high tension switchgear, the switch yard is generally located on the surface, the power and control cables being carried in trays and conduits, located in tunnels and shafts. Though the routing of those cables in a modern station are highly complicated, their overriding importance justifies extensive studies for an efficient lay-out. Facilities like stairways and ladders for periodic inspection, maintenance and repairs, if necessary, of the cables should be provided. Governors, oil pumps, raw water systems for generator and transformer cooling, carbondioxide fire protection systems etc are all located suitably in the machine station. In addition, facilities of drinking water supply, toilet room, penthouse, water closets, lounges etc., both for station service personnel and visitors are provided in the station.

Ventilation

Ventilation is indeed a complex problem in an underground power station. Exhaust fans, fitted at the exit end of shafts create the necessary draught. The number and capacity of these fans are fixed with reference to the space volume of the power

(*Continued on page 28*)

'LISSAPOL' N *in Concrete Mixes*



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- Has no chemical effect on the mix
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New Power Supply System for Cyprus

In 1946 the Government of Cyprus embarked upon a ten-year, £10,000,000 programme of development, and tremendous progress has since been made in afforestation, irrigation and improved farming methods. In conjunction with this programme the Government also embarked upon an island-wide electrification scheme the first stage of which is estimated to cost £2,500,000.

An enlarged and unified power system for the whole island is necessary as the supply was previously confined to a few municipalities, and to private generating plant owned and operated by mining companies and other organisations. The total capacity of this plant was approximately 10,000 kW but the new scheme, when completed, will comprise a 70 MW generating station at Dhekelia, in the South-East of the island, together with a comprehensive distribution system.

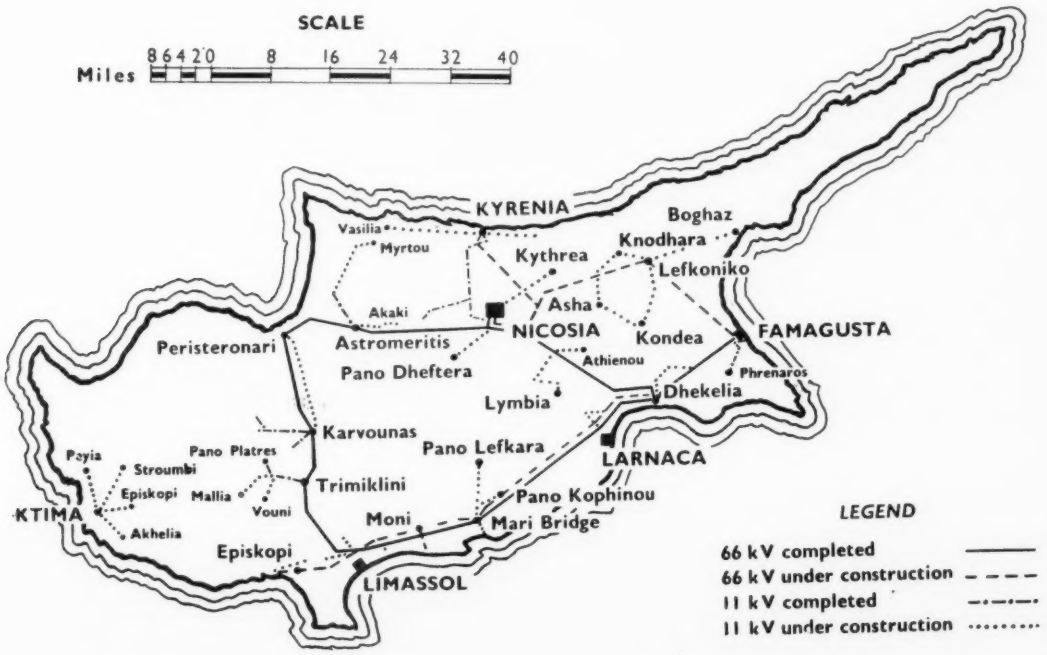
The first stage of the electricity scheme, now completed, included the building of the first part of the power station — with 28 MW of plant installed — and the erection of 66kV and 11kV transmission lines to provide supplies to most of the principal towns and to the main mining and industrial areas.

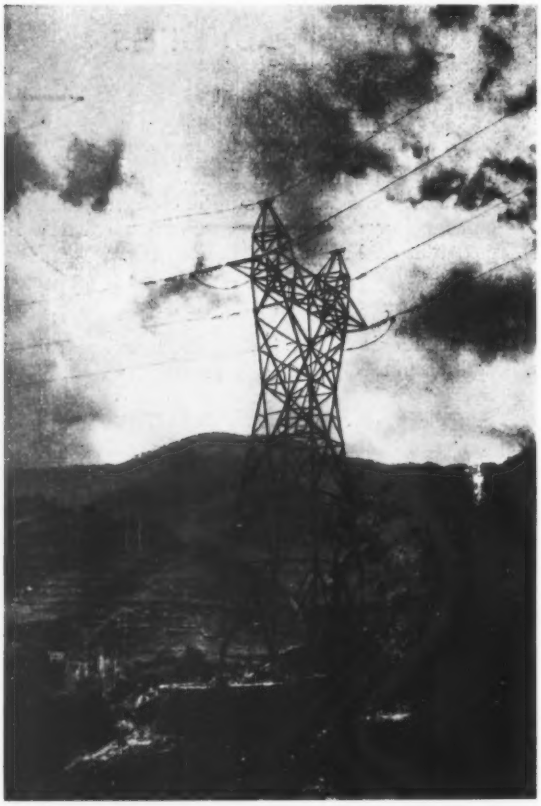
A number of British firms were closely associated with this work, including British Insulated Callender's Construction Co. Ltd. who were responsible for the supply of materials and equipment, for the construction of the transmission lines and distribution systems and who also installed the power cables in the power station. The consulting engineers were Messrs. Preece, Cardew and Rider, and the civil engineering work on the power station was carried out by Messrs. Scott & Wilson, Kirkpatrick & Partners.

Power Station

Dhekelia Power Station which is erected on solid rock foundations on the foreshore near Larnaca is a steel-framed building of semi-outdoor construction. It is divided into three main sections comprising turbine and feed heater bays, auxiliaries bay and boiler bay. The turbine bay is open below the operating floor level and has a removable roof. The boilers are entirely outdoor with an enclosed firing aisle and the auxiliaries bay has the main 415-volt auxiliary switchroom and offices located over it. The 11kV switch house, control room, main step-up transformers, 66kV outdoor switching station stores and and workshops are located outside and on the landward side of the power station.

Three oil-fired boilers are installed and the fuel is brought to the station by tankers which are accommodated in a prepared deep water anchorage approximately 400 yards off shore. The oil is discharged through a submerged pipeline into three welded steel storage tanks erected 200 yards from the main buildings.





32180 A 66kV steel section tower wite 1500 foot span in the mountainous area. This tower, in common with a number of others, had to be provided with special foundations because of the steep angle of the ground.

Associated with the boilers are three turbo-alternator sets — Nos. 1 and 2 each rated at 7 MW and No. 3 at 14 MW — generating at 11kV 3-phase 50 c/s. The output from each set is taken by seven single-core. 40 sq. inch cables to the main 11kV switchroom. The cables from Nos. 1 and 2 sets are approximately 165 yards long, of which 120 yards are laid direct, the remainder being in ducts or cleats, while the cables from No. 3 set are 135 yards long and are laid through the cable tunnel connecting the main station building to the switchroom basement.

For house service use a 750 kW 415-volt diesel alternator is installed in the main building and the out-put is fed to the auxiliary station switchboard by ten single-core. 40 sq inch low tension cables. The station auxiliaries operate from a 415-volt system at present comprisng two sections of switchgear which will be developed to four sections. Each section is supplied from a 1000 kVA 11,000/415-volt transformer. Each transformer is connected to the 11kV switchboard by a three-core, 20 sq inch lead-sheathed and wire armoured cable and is connected to the L. T. switchboard by 10 single-core .40 sq inch cables which are routed along the cable tunnel.

Cooling water for the condensers is picked up and discharged into the sea through two channels, the intake and outfall being 140 yards apart; boiler make-up water is taken from the intake channel and fed to the evaporators.

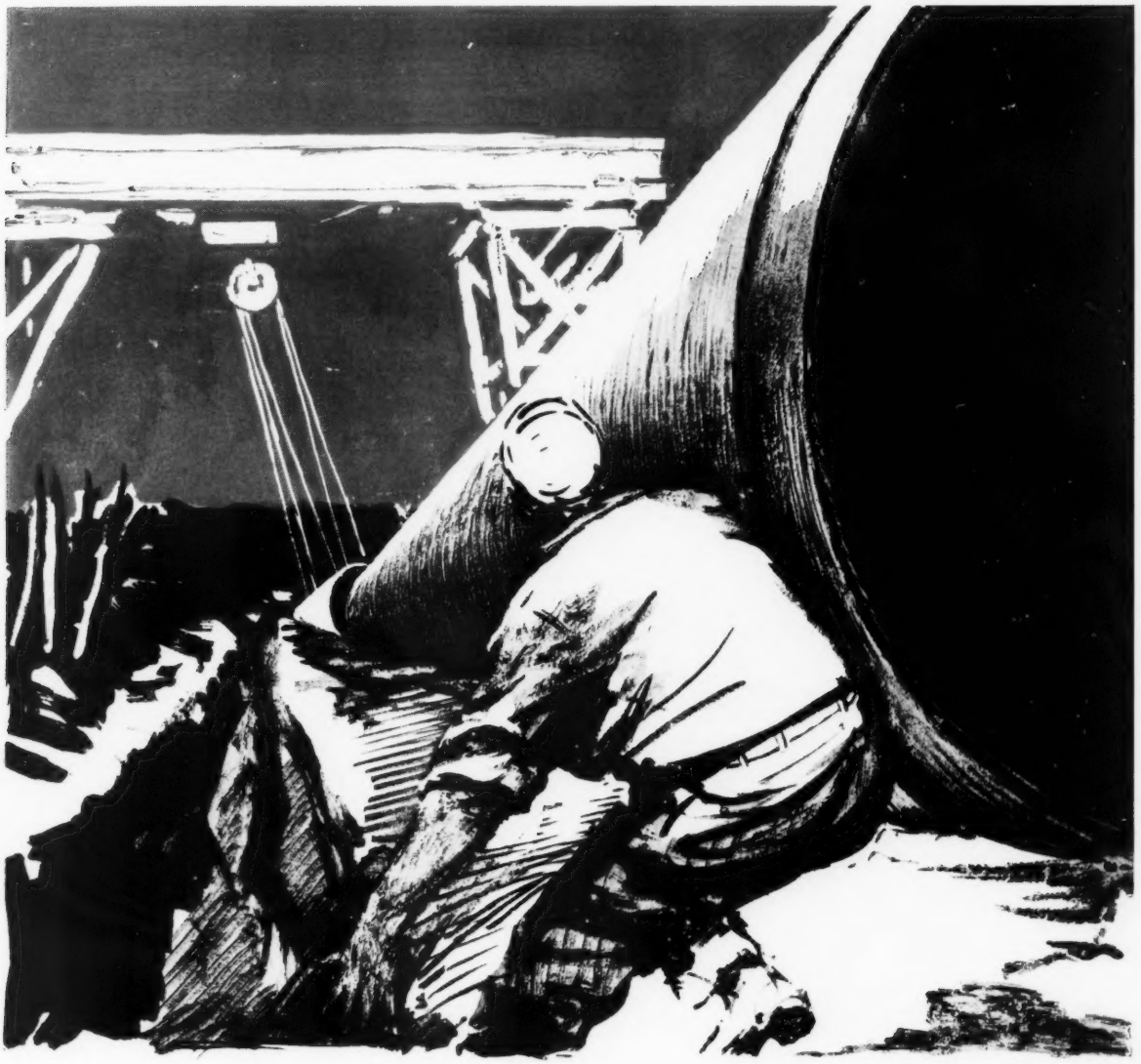
One of the main station earths which consists of coils of soft drawn copper strip 2 inch $\times \frac{1}{4}$ inch suspended on spacing formers in the cooling water culverts, was also supplied and installed by the BIC Construction Co. Ltd. The second earth is a plate in a deep pit in the 66KV switchgear compound.

The outgoing power from the main 11KV switchboard is fed to each of the two 15 MVA line transformers by six single-core. 40 sq. inch cables. The 11/66 KV transformers and their switchgear are of the outdoor type, and are located in a switching compound.

All single-core cables are laid in trefoil formation, and all lead sheaths are bonded to the station earth at each termination. These cables have a plain lead finish where cleated, but have a served finish when laid direct. All multicore cables are steel wire armoured.

The first section of Dhekelia Power Station has

An 11KV angle wood pole on the single-circuit line between Kyrenia and Nicosia. In the main. the 11KV lines consist of three copper conductors in horizontal formation without earth wires although the latter have been supplied in the mountainous regions where snow loading is expected.



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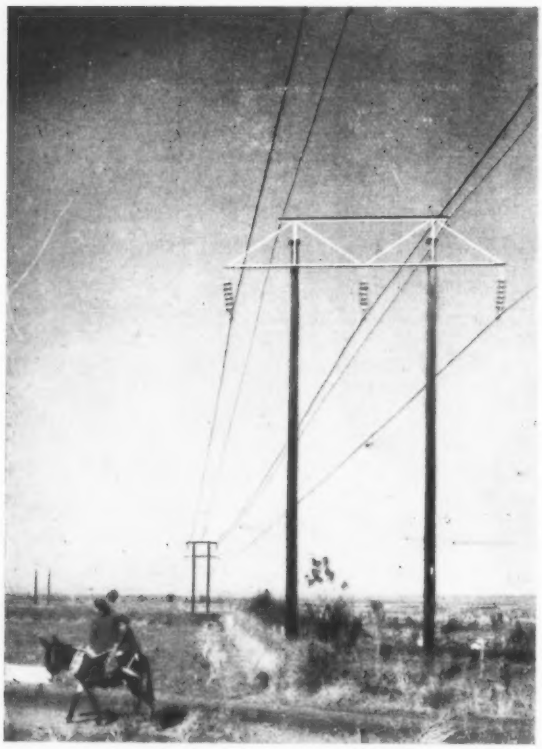

32199 A 66kV double wood pole line crossing a road between Nicosia an Astromeritis. The terrain of Cyprus makes the donkey a useful means of transport and in the erection work in the mountainous regions they proved invaluable for transporting cement, ballast and tower materials to the sites, although in many cases the tracks had first of all to be cut out of the mountainside.

been on commercial load since the beginning of 1953 and work on the second stage is now being carried out.

This first extension to the power station, comprising one 14 MW turboalternator set and two boilers, is now in hand for completion by August, 1956, and a further extension to provide another 14 MW turboalternator and one more boiler is planned for completion by September, 1957.

Transmission Lines

Towards the end of 1949, and througout 1950, surveyors of the BIC Construction Co. Ltd. were surveying the routes for the 66kV overhead lines. Although these are mainly on the plains, one section crosses the Troodos range of mountains, reaching a height of 4,000 feet, and one line passes only 400 feet lower than the summit of Mount Olympus (6,406 feet). Construction work was started in 1951 and the Company's staff, working in a supervisory capacity under the direction of the Cyprus Electricity Authority, have been responsible for the erection of 161 miles of 66kV and 57 miles of 11kV lines.

From the switching compound at Dhekelia run three single-circuit 66kV lines two of which form the central ring via Nicosia, Astromeritis, Peristeronari, Karvounas, Trimiklini, Limmasol, Mari and Larnaca while the third circuit is to Famagusta. Provision has been made for the duplication of the circuits Dhekelia-Nicosia, Dhekelia-Limassol, and for an eastern ring from Famagusta via Lefkoniko to Nicosia.

The construction of the 66kV lines comprises 7/.161 inch steel-cored aluminium conductors in horizontal-formation at 13 feet spacing. The conductors, and two overhead galvanised steel earth wires, are carried on twin wood poles 44 feet high with steel cross arms, except for a three-miles stretch over War Department property near Dhekelia (where steel

Dhekelia Power Station

(*Continued on page 26*)

Our Delhi Letter

(From our special correspondent)

The floods to which most of the States in the Northern and Eastern Zones of this sub-continent have been subjected, may be regarded as Nature's clear warnings that the battle for security from drought is no more important than the struggle that must be continued against devastating inundation by Rivers and the God of Rain.

The wrath of Indra has been demonstrated on the hills and planes of Uttar Pradesh, Bihar, Orissa and lastly Punjab, Pepsu and Delhi. One has only to see the headlines of the country's newspapers for the last 8 weeks to get an idea of the colossal dislocation and misery that have been visited on the people through floods and abnormal precipitation.

Necessity of Proper Drainage

As in many other things, so here, it is our roving Prime Minister who has given the signal in the right direction. By all means, have the flood control works like dams, barrages and dykes, but do not forget that it is the blocking of drainage or the lack of it, that produces submergence of large areas or the cutting up of rail and road communications. Let these drainages be opened up by the provision of adequate waterways in our bridges and through our embankments. It is false economy if in any scheme of railways, roads or irrigation, the planners do not provide for drainage on the plea of economy. The loss to the nation because of such short-sighted economies is great.

Systematic and Comprehensive Flood Control

The same philosophy of thoroughness applies to flood control projects. Attempting to contain the river between two "Man-made flimsy walls" is neither scientific nor successful. We have to bank on reservoirs, soil conservation measures and embankments. Also the low lying areas have to be distinguished from other places and local protection to the people has to be given greater emphasis than any long range slow scheme of diversion of a river or its containment. As pointed out by Home Minister Pant, the people have to think and decide in terms of their livelihood on a long-range basis. If nine years of flood-free occupation of land gives them more income than the loss of the tenth year when floods overpower them, they have still to decide whether to quit or to stay on the balance of advantages. And tradition, certainty of livelihood and the resultant benefits are in many cases against leaving the homestead and the forefathers' fields. This human aspect (and economic picture) should convince the planners that permanent displacement and resettlement should only be accepted in the last resort, for example, within the area of a lake or a reservoir which will form behind a dam.

Tempo of Execution

Even so the pace of construction of flood protection works or of the other dam and barrage and canal projects needs to be hastened. The gaps in the agricultural economy of the people are so wide that drought and flood which hit the country, need to be insured against. And the expansion needed in employment and industry call for a quicker completion of many of the country's hydro-electric projects. Work at some of the projects is unfortunatelty, going on in a slow and disjointed fashion.

National Construction Corporation

The deficiencies are not unexpected because the size and intensity of the programmes of the First and Second Five Year Plans greatly out-strip any precedents of public endeavour, the ideals of the Welfare State and socialistic pattern of society call for a huge building programme and increase in production. Except for a few outstanding examples, the yields of private enterprise has remained dormant and the policy of waiting on the fence and restricting the enterprises to industries with guranteed profits has cramped the country's economy. But now the targets are such that maximization of effort is needed to secure achievement on the planned scale.

Bhakra and Rihand Dam Examples

As private enterprise in the field of River Valley Projects has in the past been restricted to small works largely executed with hand labour methods, there is extreme paucity in the country for organizations which can tackle big works like the Bhakra, Rihand, Koyna and the Nandikonda Projects. After protracted deliberations and negotiations, the Bhakra Dam work was undertaken departmentally and the advantage of this decision have already become incontestable. This work is proceeding according to schedule despite the stupendous technical and organizational problems and difficulties. When the Union Government desired the same procedure to be followed for the Rihand dam, the U.P. Government expressed their inability to be able to gear themselves for departmental execution, and the work had to be alloted to a private firm. Now there is nothing wrong in such works being done by private firms of repute. But how many firms of such a category exist in the country? Are we going to sit and wait till more firms grow? And in what way can such inexperienced firms ensure the sound and economical execution of our urgent projects?

Government must step in

Since the country's development which aims at increased agricultural and industrial production cannot brook of delays, there is utmost need for pooling of all resources and harnessing them to give a maximum outturn. As long as the country's works remain dependent on the sole initiative of priyate enterprise, the size and targets of the plan will be sorely handi-

capped. There is urgent necessity for a Construction Corporation in which the various States may associate as partners. The idea was mooted and thrashed out out in the Engineers' Seminar held last July at Srinagar. It has been further elaborated by an ad hoc Committee presided over by Secretary, Irrigation & Power Ministry. The principle of the Corporation is to be put before the ensuing meeting of the Coordination Board of Ministers. Apart from the resistance and inertia which are to be expected against every new proposal (whatever its merits) the arguments in favour of such a Corporation are unquestionable. It will still leave the States and the private sector enough work to show their own initiative and capacity. Only the more complicated and highly mechanized jobs will be entrusted to such a Corporation.

Central Pool of Machinery and Equipment

At present each Project maintains its own restricted reserve of plant and machinery with the unavoidable handicaps of breakdown, difficulty in spares, repairs etc. After the work is completed, the plant lies without proper care and the work of over-hauling etc. is delayed till such time as the next project can be found where such equipment can be made use of. If a Construction Corporation for the country as a whole is brought into existence, such equipment will find a definite destination after each job is completed. It can, in fact, be made a standing order that such machinery is not allowed to remain in imperfect condition even for a day. Overhaul and repairs will be mandatory and due care will be taken for storage and stocking of spares. The projects will be benefited by the economy that will result from such a procedure.

Pool of Personnel

In addition to plant and machinery a pool of experienced personnel would be created. This pool will absorb all talent and experience which are available in the country but are surplus or spare from the needs of any one State. At the moment no State can afford to maintain in full strength the staff and skilled workers who are free after a project has been completed. Moreover, there is a shortage of talent at the higher levels and it is important that their know-how is made available to the entire country in order to get maximum results within the limitations of resources, of materials, and of funds and other auxiliaries.

It is hoped that the idea of the Construction Corporation will receive the whole-hearted support of many States. In fact, not only one Corporation but many such Corporations may be considered necessary in the near future.

(*Continued from page 24*)

New Power Supply System for Cyprus

towers were used to give greater ground clearance) and a 23 mile stretch in mountainous country where towers necessary owing to the rigorous weather conditions, also a short section between Karvounas and Limassol where the route required longer spans than those afforded by wood poles.

Switching and transforming stations are provided at various points on the 66 kV ring main, and section switches are installed at Trimiklini, Karvounas and Peristeronari, to isolate that section of the line which is in mountainous country and liable to damage through severe weather conditions. Switching stations are located at Nicosia and Limassol, and transforming stations at Mari, Trimiklini, Karvounas, Peristeronari, and Astromeritis. A transforming station is also provided at Famagusta, on the third circuit which can be converted to a switching station if required during completion of the later stages of the new electricity supply scheme.

The distribution of electrical energy is by 11 kV overhead lines from the switching and transforming stations, with the three copper conductors carried on wood poles, in horizontal formation, without earth wires. In the mountainous region the 14 miles of line have been designed for snow loading, with the conductors in triangular formation and the addition of two earth wires.

Although very few Cypriot workmen had previous experience of erecting overhead lines, they were quick to learn and were soon trained to a reasonably high standard of efficiency under the guidance of BIC Construction Co. engineers and linesmen erectors. The excavation of rock which is found over much of the island was a slow and tedious job necessitating the use of compressors for most of the excavation work. Where access was very bad — particularly in the mountainous region — donkeys were used to transport the cement, ballast and tower materials to the sites. This, in turn, required considerable preparatory work as donkey tracks had first to be cut, often in the side of the mountains themselves.

Most of the municipal electricity undertakings have now been absorbed into the Electricity Authority of Cyprus. Some of the areas previously served by them together with a number of mining and other companies are being supplied wth electricity, mostly at 11kV, whilst other consumers are connected to low tension networks fed by 11,000/400-volt distribution transformers.

With the first stage of the island's electricity programme now completed, work on the second stage is making rapid progress and in due course Cyprus will be in possession of a very comprehensive power distribution network.

Editorial

Floods again

The year 1954 was characterised by heavy floods in the country. 1955 has repeated the performance, this time especially affecting Uttar Pradesh, Orissa, the Punjab and PEPSU. Pakistan's western wing was also heavily damaged by floods. The rainfall in Uttar Pradesh in July was abnormally high as can be seen from the following figures quoted by Dr. Sampurnanand, Chief Minister of U.P. :

District	*Normal for July (inches)*	*From July 1 to 23 '55 (inches).*
Faizabad	11.91	68.75
Jaunpur	11.89	53.18
Sultanpur	12.09	32.62
Basti	14.34	53.21
Pratapgarh	11.32	32.48
Bahraich	12.23	26.23
Azamgarh	11.99	20.68

The worst was the one ending July 23 when the rainfall in some districts was eight imes more than the average downpour.

In Utter Pradesh, Orissa, and the Punjab embankments gave way. The river changed its course seriously affecting the headworks as well as the canal system of the province. It is necessary to investigate the causes of this abnormal character of the rainfall. Is it in any way related to the effects of atomic explosion experiments carried out this year or on previous years as explained in our editorial some time back (Vol. 5 No. 3) and as subsequenty substantiated by a paper submitted by a French scientist during the Geneva Conference on Peaceful Uses of Atomic Energy held in August this yead ? The meteorologists in our country should be able to throw seme light on the subject.

Meanwhile Prime Minister Jawaharlal Nehru has made some very interesting and thought-provoking comments on the subject of floods during his recent visit to Orissa to see the flood-affected regions. He made the sensational remark : "I am almost becoming anti-dam minded." His line of thought can be judged from the following extracts from his speech.

He "called upon the people to reorientate their attitude to floods and to have greater drainage facilities for flood waters rather than confine them within embankments and dams." "It was wrong to think in terms of putting two high walls around a river and make it run to the Sea. It is silly. It may or may not protect but it prevents the countryside from being benefited by the river's floods which bring in rich silt deposits." Referring to protection works, he said : "While dams and protective works are necessary in some cases, there is a certain risk also. Each dam affects the natural drainage system and therefore might create new problems. No dam or embankment should be built without the most careful consideration of the consequences of changing natural drainage."

"There are two approaches to this problem—one is to control the river, and the other is to encourage the waters to spread out and be drained away quickly. I am not an expert to give an opinion but my own inclination is generally against dams unless a clear case is established for them. We have to think in terms of the long future—that is, not for the next year or two—and we must not do any thing which might come in the way of future enrichment of the soil."

This is an approach which cannot be disregarded off hand, not because it comes from the Prime Minister, but because it appears to contain a fair degree of sound commonsense. It will be well to remember in this context the line of thought often presented through these columns as well as elsewhere by Mr. S. C. Mazumdar, I.S.E. (Retd.) when dealing with the Ganga Barrage Scheme or in his Report on the Hirakud Project. He laid emphasis on the drainage aspect of the function of a river.

The recent experiences in America of the large number of dams constructed a decade or two ago also enables us to caution our enthusiasm for dams.

Let us hope that with these remarks of our Prime Minister, our engineers will re-assess the whole approach to the flood problem in this wider context.

(*Continued from page* 19)

Underground Hydro Electric Power Stations

station, including the several tunnels, shafts and the frequency of cycles of fresh air circulation desired in the station. If necessary, inlet fans may be located at the entrance to effect the suction of fresh air. Propeller fans or centrifugal fans, with the necessary louvers and shutters are employed for the purpose. As the air has to traverse long lengths of tunnels and shafts before reaching the machine station, it loses a substantial portion of its velocity and if it should carry suspended dirt, there is a tendency for the deposition of the dirt particles on the delicate machine parts. This is injurious to the the machines and entails a high maintenance expenditure and may eventually damage the precision equipment. To obviate or atleast minimise the effect automatic air-filter structures may be installed, and thereby prevent a direct entry of the the dirtladden air into the station. Essentially, the air filter structure comprises of an endless band made up of perforated plates suspended from a drum. These plates are coated with an odourless oil or filter liquid and the lower portion of the band is dipping into a reservoir of the same filter fluid. The band has a very slow movement facilitating the cleaning up of the plates and renewing of the oil coating. Actually air passes twice through these perforated plates, thereby assuring a fairly high degree of purification. In front of the air-filter structure a trash arrester, say a rigid wire mesh may be set, to check any large sized debris from entering into the power station. Also, as the station is located deep below in the underground and because of its relative proximity to the reservoir, there is bound to be a high humidity present in the station. Dehumidifiers may advantageously be installed to minimise the inconvenience. A smooth inlet and exhaust of the air and its free circulation throughout the station is ably assisted by the provision of louvers and shutters.

Architectural Treatment and Station Lighting

Fairly smooth wall surfaces and the arched roof, painted with light shades, matching well with the several machine parts and equipment ably satisfies the essential requirements. Glossy paints and varnished surfaces are sources of glare and consequent strain. Contrasting deep shades should as far as possible be avoided. An artificial ceiling may be provided for the vault, the same being utilised for catching and guiding the seepage water, if any, to the station sump by means of suitably designed mains and submains. This incidentally presents a better aesthetic appearance. This involves additional openings in the ceiling, fixed with suitable louvers for ventilation. With such a harmonious painting combination and with adequate station lighting, the station should be architecturally attractive. Station lighting should be adequate to permit comfortable seeing and absence of eyestrain. Instead of visible pendants and direct lighting, concealed lamps with diffused lighting are preferable and more attractive. The numerous power and control cables are as far as practicable carried in conceiled conduits and tunnels, lest they should mar the appearance of the station.

Conclusion

Underground hydro-power station development is essentially an economic proposition. The success of such a development on a few pilot schemes is bound to popularise such a construction. Experience gained on such a construction will be an invaluable asset for the country's development in several other situations of similar possibilities. The economics is even more prominent, if the broken rock derived from the power station and the accompanying shafts and tunnels are successfully utilised on the dam construction. Further, it is gradually being felt that for high head installations, the pressures in the penstocks become excessively high, demanding prohibitively uneconomical liner plate thicknesses. To effect economy in this regard, it is felt desirable to set them in tunnels and shafts. This does not however, obviate the necessity for the liner plate, though greatly economises on the quantity of steel consumption.

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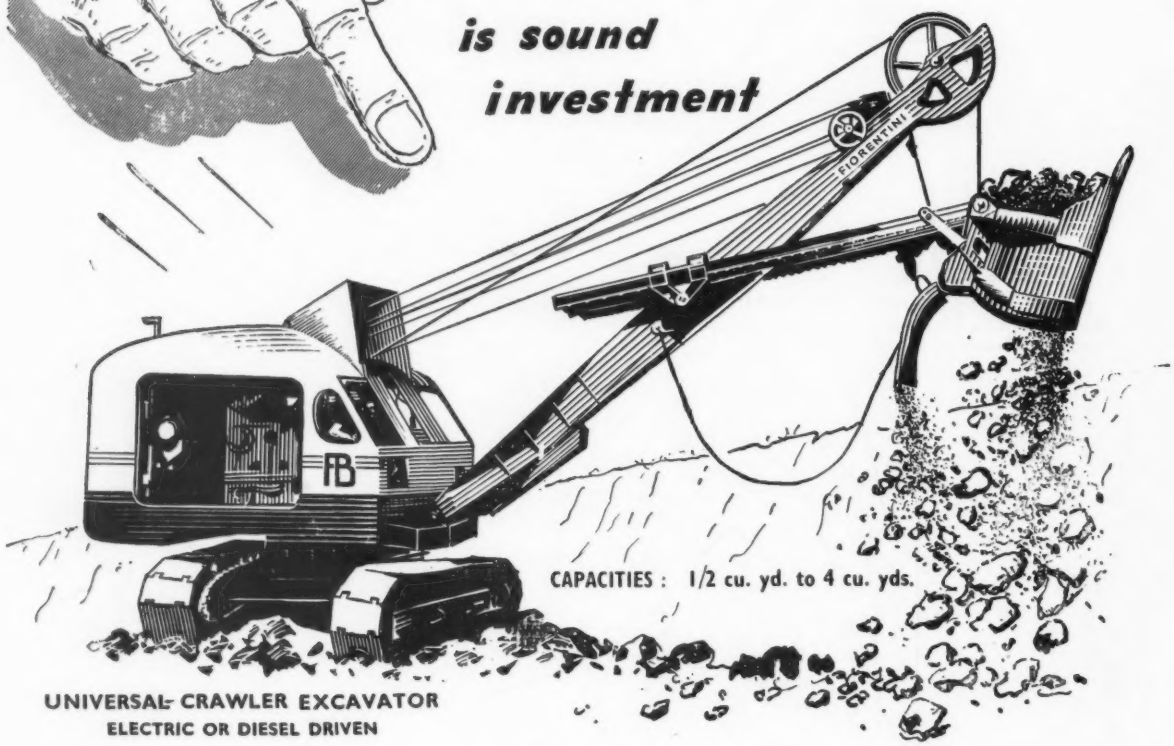

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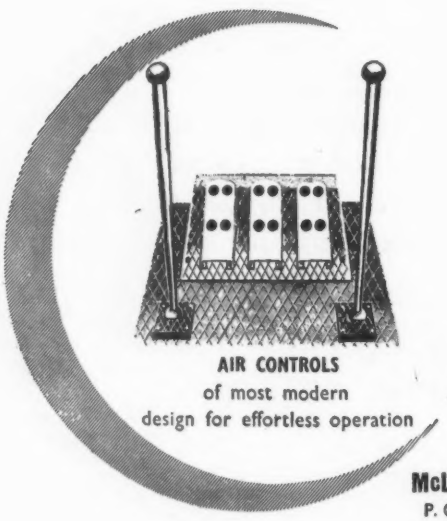

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